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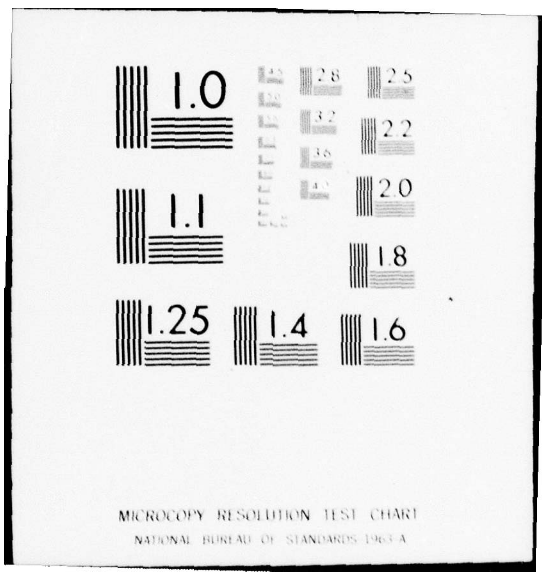
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LEVEL II

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# REPORT OF STUDY OF

# TANKER SAFETY AND POLLUTION PREVENTION REQUIREMENTS

# FOR U. S. TANKERS IN DOMESTIC TRADE

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**Prepared for**

**U.S. DEPARTMENT OF TRANSPORTATION**
**United States Coast Guard**
**Washington, D.C. 20590**

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16. Abstract

This report presents results of a study to determine if tanker safety and pollution prevention measures in addition to those contained in 1978 Protocols to SOLAS 74 and MARPOL 73 agreements should be applied to U.S. tank vessels in domestic trade. The study examined the risks associated with the marine transportation of oil by U.S. tank vessels in domestic trade, looking at the present and projected U.S. flag tank vessel fleet, oil movements by these vessels, and resulting hazards to people, property, and the marine environment. Possible preventative actions, including extension of ship construction and equipment requirements contained in 1978 Protocols to SOLAS 74 and MARPOL 73 to smaller tankships, were identified and examined. Estimates were made of: (1) the impact of possible preventative actions on accidental and operational oil discharges and damage to the marine environment, (2) tankship fires and explosions, and (3) transportation costs and capital requirements.

On the basis of information presented in the study, a key recommendation is the adoption of additional measures to control oil discharges from possible future transportation of OCS oil to shore by U.S. tank vessels. Requirements for segregated ballast tanks or clean ballast tanks should not otherwise be extended to smaller U.S. tankships in domestic trade. Specific actions are recommended to obtain better information on quantities of oil discharged and effects on the marine environment and to improve compliance with regulations already in effect.

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## EXECUTIVE SUMMARY

This report presents results of a study to determine if tanker safety and pollution prevention measures in addition to those contained in 1978 Protocols to SOLAS 74 and MARPOL 73 should be applied to U.S. tank vessels in domestic trade. This evaluation was conducted during May and June 1978 by a Coast Guard study group which included participants from a number of other Federal Executive Branch agencies. The main concern prompting this study was that tankers of less than 40,000 DWT are not subject to some of the construction and equipment requirements included in the MARPOL and SOLAS Protocols. Specifically, (1) new product tankships of under 30,000 DWT are not required to be built with protectively located segregated ballast tanks and are not required to have segregated ballast capability; (2) existing crude oil tankships of under 40,000 DWT are not required to have clean ballast tanks (CBT) or segregated ballast tanks (SBT) or crude oil washing systems (COW), and may be exempted from inert gas system (IGS) requirements if high capacity washing machines are not fitted and, in the Coast Guard's judgement, the ship's design characteristics make it impractical to fit IGS; and (3) existing product tankships of under 40,000 DWT are not required to have CBT or SBT, or IGS if high capacity washing machines are not used.

This study examined the risks associated with the marine transportation of oil by U.S. tank vessels in domestic trade, looking at the present and projected U.S. flag tank vessel fleet, oil movements by these vessels, and resulting hazards to people, property, and the marine environment. A number of possible preventative actions, including extension of ship construction and equipment requirements contained in the 1978 Protocols to SOLAS 74 and MARPOL 73 to smaller tankships, were identified and examined. Estimates were made of the following: (1) the impact of possible preventative actions on accidental and operational oil discharges and damage to the marine environment resulting from oil discharges, (2) incidence of tankship fires and explosions, and (3) transportation costs and capital requirements.

Tank barge construction and equipment standards were excluded from the scope of this study since they are covered by another Coast Guard study directed by the President. As a result of the tank barge study, the Coast Guard has initiated a regulatory project which will propose double hull construction for new oil tank barges and explore various possible methods for treating the existing tank barge fleet to prevent pollution caused by hull damage.

Study estimates indicate demand for U.S. tankships in domestic trade in the size range of 5,000 DWT to 40,000 DWT will decline by about 40%. from 3.9 to 2.2 million deadweight tons, between 1978 and 1985 due to development of new pipeline capacity. Development of one or more crude oil pipelines from the West Coast to mid-continental refineries is expected to eliminate the need for smaller tankships currently used in the trans-Panama route for Alaskan crude oil. As a result, U.S. tankships in the 5,000 DWT to 40,000 DWT size category will, in 1985, be engaged almost exclusively in the carriage of petroleum products, except for vessels which may be used to transport Outer Continental Shelf crude oil

ashore where pipelining is not feasible. Because of declining demand, it is not anticipated that there will be a significant building program for vessels of this size for domestic trade in the near future.

The maximum potential impact (based on most pessimistic estimates of degree of compliance with discharge standards already in effect) of extending TSPP requirements to tankships under 40,000 DWT in domestic trade is a reduction in accidental and operational oil inputs of an estimated 19,300 metric tons (144,750 barrels) per year. Of this total, measures which would prevent collision, ramming, and grounding accidents to U.S. tankships in domestic trade might, if they were 100% effective, avoid an average of 9 collisions and rammings and 6 groundings per year with total estimated outflow of about 1,300 metric tons (9,750 barrels) per year. The actual impact of accident prevention measures could be expected to be something less than this maximum possible impact, depending on the effectiveness of measures actually implemented. The remainder of this maximum potential reduction (some 18,000 metric tons or 135,000 barrels per year) theoretically might be achieved by requiring SBT or CBT on existing tankships under 40,000 DWT in domestic trade. The actual impact of SBT or CBT requirement could be considerably smaller than this maximum potential amount, depending on the degree of effectiveness of the other discharge control measures already in effect. Uncertainty over present and projected degree of compliance with operational discharge standards now in effect makes more precise estimates impossible to make at present. It is not possible to say what impact this maximum potential oil outflow reduction might have on the marine environment, except in general terms as outlined in Section 2.3.3 of the report.

Tankships and tank barges which may be used in the future to transport OCS oil to refineries ashore represent a different problem from vessels involved in coastwise product movements. Treatment and disposal of oily mixtures from ballasting and tank washing from OCS tankships in compliance with existing discharge standards solely by use of load on top procedures does not appear feasible. Future transportation of OCS oil could also result in an increase in accident risk in some coastal areas.

Action to extend IGS requirements to existing product carriers under 40,000 DWT could be expected to have only a minor impact on the relatively low incidence of fires and explosions on these vessels. This, coupled with expected severe installation problems and relatively high cost of installation makes this measure not worthwhile.

Cost estimates indicate extension of TSPP requirements to smaller U.S. tankships in domestic trade would mean $100-$150 million per year in increased transportation costs by 1985, representing a 32-44% increase in transportation costs. This would correspond to an increase of about 0.5 to 0.75 cent per gallon of oil transported. Capital cost for the domestic fleet range from near zero to $215 million for the various alternatives examined.

On the basis of the study, a key recommendation is to adopt additional measures to control oil discharges from possible future transportation of OCS oil to shore by U.S. tank vessels. SBT, CBT, Specific Trade, and Special Ballast measures to control operational discharges, should be considered, although any requirements adopted should allow sufficient flexibility to adopt new technological solutions. Transportation planning for OCS development should be monitored by the Coast Guard, and when potential increases in tanker traffic are identified, the Coast Guard should reappraise applicable vessel surveillance and control systems, vessel navigation system requirements, and aids-to-navigation systems in areas where traffic increases are expected, making appropriate changes to eliminate or control hazards due to increased tanker traffic.

TSPP requirements for SBT or CBT should not otherwise be extended to smaller U.S. tankships in domestic trade. Action should be initiated to obtain better information on present and projected quantities of oil discharged to the marine environment from product carriers in domestic trade and the effects of these discharges on the marine environment. Specific actions to gather information, many of which will also serve to improve compliance with the current discharge standards, are described in the RECOMMENDATION's section of the report.

The Coast Guard should also continue and expand its program for boarding U.S. tank vessels at loading and discharge terminals, since experience indicates this can markedly improve the degree of compliance with regulations already in effect.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

# 1. INTRODUCTION

## 1.1 PURPOSE

The purpose of this report is to document the results of a Coast Guard study to determine if additional tanker safety and pollution prevention measures beyond those specified in MARPOL and SOLAS Protocols of 1978 can and should be applied to U.S. oil tank vessels (tankships and tank barges) operating in U.S. domestic trade, and, if additional measures are needed, what those measures should be.

## 1.2 BACKGROUND

Public concern over risks associated with marine transportation of oil following a series of oil tanker accidents in and near U.S. waters during the winter of 1976-1977 resulted in the announcement by President Carter on March 17, 1977, of a series of measures intended to reduce such risks. The President's message is reproduced in Appendix A. Among the measures recommended was a call for a special international conference to consider U.S. proposals for improvements to the international system of tanker inspection and certification and strengthening of ship construction and equipment standards. As a result, the International Conference on Tanker Safety and Pollution Prevention (TSPP) was held in February 1978 under the auspices of the Inter-Governmental Maritime Consultative Organization (IMCO). This conference adopted important new measures to improve the safety of oil tankers and help prevent pollution of the seas from ships. A summary of ship construction and equipment requirements is given in Table 1.

As a result of the tonnage levels established at the Conference, approximately 200 U.S. vessels in the domestic trade would not be affected by new construction and equipment standards. This raised questions within the Administration about whether or not these standards might be imposed on U.S. flag oil tankers in domestic trade down to lower tonnages. Deputy Secretary of Transportation Alan Butchman asked the U.S. Coast Guard to undertake a study of the feasibility of extending TSPP Conference results down to lower tonnages for U.S. tankers in domestic trade (reference 2). In response to Secretary Butchman's request, the Coast Guard proposed in reference (3) a study of slightly broader scope to cover other concerns and suggested improvement measures identified through recent contacts with other agencies, state representatives and in Senate and House hearings. Involvement by representatives of other Federal Agencies, much as was done during preparation for the TSPP Conference was also proposed. This expanded scope study was approved by the Secretary along with an extension of the deadline to June 30, 1978 for receipt of the study by Mr. Butchman.

Table 1

**TANKER SAFETY AND POLLUTION PREVENTION CONFERENCE RESULTS**

**Ship Construction and Equipment Requirements**

| Tank Vessel | | Requirement (Construction feature, vessel tonnage, Date required) | |
|---|---|---|---|
| **New Vessels**<br>**Determining Dates**<br>**6/79 Contract date**<br>**1/80 Keel laying**<br>**6/82 Delivery** | Crude Oil | PL / SBT COW IGS | 20,000 DWT and over (Note 1) |
| | | Second Radar<br>Steering | 10,000 GT and over at HS (6/79) |
| | Petroleum Products | PL / SBT | 30,000 DWT and over |
| | | IGS | 20,000 DWT and over |
| | | Second Radar<br>Steering | 10,000 GT and over at HS (6/79) |
| Existing Vessels | Crude Oil | CBT or SBT or COW | 40,000 DWT and over at HM (6/81) then → SBT or COW: 70,000 DWT and over at HM+2 (6/83); 40,000 to 70,000 DWT at HM+4 (6/85) |
| | | IGS | 70,000 DWT and over at HS+2 (6/81)<br>20,000 to 70,000 DWT at HS+4 (6/83) (Note 2) |
| | | Second Radar | 10,000 GT and over at HS (6/79) |
| | | Steering | 10,000 GT and over at HS+2 (6/81) |
| | Petroleum Products | CBT or SBT | 40,000 DWT and over at HM (6/81) |
| | | IGS | 70,000 DWT and over at HS+2 (6/81)<br>40,000 to 70,000 DWT at HS+4 (6/83) (Note 3) |
| | | Second Radar | 10,000 GT and over at HS (6/79) |
| | | Steering | 10,000 GT and over at HS+2 (6/81) |

**Note:** Dates in ( ) are dates by which Resolutions 1 and 2 adopted by the Conference recommended putting these requirements into effect, without waiting for entry into force of the Protocols.

**Footnotes:**

1. An inert gas system (IGS) is required whenever a tanker uses crude oil washing.
2. Between 20,000 and 40,000 DWT, the Administration of a Flag State may grant an exemption to the requirements for IGS if high capacity washing machines (i.e., tank washing machines having an individual throughput of greater than 60 cubic meters per hour) are not fitted and the ship's design characteristics make it impracticable to fit IGS.
3. Tonnage limit for IGS is to be reduced to 20,000 DWT if tank washing machines having an individual throughput of greater than 60 cubic meters per hour are fitted.

The study was conducted during May and June of 1978 by participants from the following organizations:

President's Council on Environmental Quality
President's Council on Wage and Price Stability
Department of Commerce, Maritime Administration
Department of Commerce, National Oceanic and Atmospheric Administration
Department of Energy, Strategic Petroleum Reserve Office
Department of Interior
Environmental Protection Agency
Department of Transportation, Office of the Secretary
Department of Transportation, U.S. Coast Guard.

## 1.3 SCOPE OF THE STUDY

The main concern prompting this study is that certain smaller tankers in size categories under 40,000 DWT would not be affected by some construction and equipment standards included in the MARPOL and SOLAS protocols. (See Table 1). This study thus concentrates primarily on the possible need for and effects of extending the TSPP conference requirements to smaller tankers operating in the U.S. domestic trade. A review was made of the existing U.S. flag tankers, their present and future operations, their environment, and possible associated hazards. Preventative actions other than extension of the TSPP requirements were also reviewed briefly for their ability to eliminate or control the potential polluting events and hazards identified.

Although the term "tanker customarily includes both tankships and tank barges, the scope of this study has generally been limited to tankships. Another Coast Guard study, directed by the President, evaluating the design, construction, and equipment standards for tank barges has been recently completed. This study investigated the need for and effectiveness of various measures to avoid accidental oil outflows from tank barges. As a result of this study, the Coast Guard has initiated a regulatory project which will propose double hull construction for all new tank barges and will publish an Advance Notice of Proposed Rulemaking for existing tank barges to receive comments from all interested parties as to how the existing tank barge fleet can be treated to prevent pollution caused by hull damage. Because tank barge construction and equipment standards were covered by this other study, they were generally excluded from the scope of this study.

Environmental, economic, safety and energy impacts were determined for some of the alternative regulatory packages developed for consideration. In the environmental area, primary emphasis was placed on impacts on discharges of oil to the sea, with some attention given to impacts on air and water quality as a result of use of specific alternative actions (i.e., impact of crude oil washing).

## 1.4 STUDY APPROACH

The approach taken for this study was to carry out the following steps or tasks:

1. Define the problem, to include

   a. A complete description of the transportation system of concern

   b. A characterization of the environment in which the transportation system operates

   c. Identification of possible hazards to the environment

2. Establish feasible alternative preventative actions to eliminate or control the hazards identified

3. Evaluate alternative preventative actions to determine environmental, economic, safety, energy, and other impacts

4. Prepare recommendations as to action which should be taken.

## 2. PROBLEM DEFINITION

This section of the report defines the problem by reviewing the transportation system of concern, characterizing the environment and then carefully identifying the possible hazards to the environment.

### 2.1 DEFINITION OF THE TRANSPORTATION SYSTEM

"U.S. tank vessels in domestic trade" may be thought of as a system, where a system is defined as "any complete entity consisting of hardware, software, personnel, data, services, and facilities which transforms known inputs into desired outputs." In this case, the desired outputs are safe, efficient transportation of crude oil and petroleum products.

Three elements must be described in order adequately to define the system "U.S. tankers in domestic trade" for purposes of this study:

- The vessels
- The trade (i.e., oil movements)
- The legal framework governing operating of the system.

#### 2.1.1 Tank Vessels

The term tanker is generally used to describe vessels constructed or adapted to carry bulk liquid cargoes. In the broadest sense, tanker includes both self-propelled vessels (tankships) and non-self-propelled vessels (tank barges) and all types of bulk liquid cargoes (petroleum, vegetable and mineral oils, hazardous chemical cargoes, wine, water, etc.) A number of terms, however, are used in discussing tankers and these need to be carefully defined to avoid confusion. Appendix B presents many of the pertinent definitions, some of which are not consistent with one another.

Tank vessels may be classified or grouped according to certain common characteristics or "variables":

- Type of vessel (tankship, tank barge, combination carriers)
- Route (International voyages, Ocean, Coastwise, Great Lakes, Lakes, Bays, and Sounds, Rivers)
- Crew (manned or unmanned)
- Size (deadweight tons or length between perpendiculars)

o Cargo (crude oil, petroleum product, chemicals, grain, bulk/oil, ore/oil)

o Age (since construction or rebuilding)

There are approximately 4400 U.S. tank vessels inspected and certificated by the U.S. Coast Guard for the carriage of flammable or combustible cargoes or liquids or liquefied gases in bulk which have dangerous characteristics. Of this number, approximately 3000 are inspected and certificated for the carriage of flammable or combustible cargoes (primarily petroleum cargoes). Table 2 shows the distribution of tankships and tank barges.

Note that Table 2 includes an unspecified but small number of special purpose vessels certificated to carry liquefied petroleum gases (butane, propane, propylene) which would not normally be used to carry Grade A, B, C, D, or E flammable or combustible liquids. Table 2 does not include vessels certificated under 46 CFR Subchapter O which also may be suitable for carrying Grades A, B, C, D, or E flammable or combustible liquids.

The present fleet of "U.S. certificated tank vessels" can be broken down for purposes of this study by service, type, route, trade, and size as shown in Figure 1.

The figure "20,000 DWT" has been used frequently in the past as a lower limit breakpoint in suggested tankship construction and equipment requirements. Figure 1, however, indicates that a breakpoint somewhere between 5,000 and 15,000 DWT is probably more realistic in view of the size distribution of existing U.S. oceangoing tankships. For this reason, 5,000 DWT has been used as a breakpoint in this study in lieu of 20,000 DWT.

### 2.1.2 The Demand For Domestic Tanker Transportation Services

The fleet of U.S. flag vessels described in Section 2.1.1 has been built to meet the demand for transportation services to move oil by water. These movements can be broken down into foreign and domestic as follows:

o FOREIGN - Including foreign-to-U.S., U.S.-to-foreign, and foreign-to-foreign oil movements.

o DOMESTIC - Oil movements between any two U.S. ports.

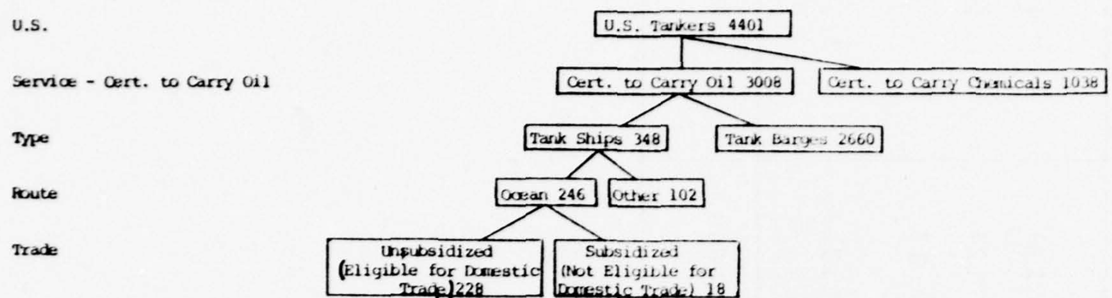
Foreign movements are not a concern of this study because such movements will be affected by actions resulting from the TSPP Conference. In understanding the demand for domestic movements, however, it is important to note that certain coastwise trades are protected from foreign flag competition by the Jones Act. This Act (Section 27 of the Merchant Marine Act, 1920-46 USC 883) provides that merchandise shall not be transported

TABLE 2

Tank Vessels Inspected and Certificated by the U.S. Coast Guard for Carriage of Oil

| Type of Vessel / Route | Tankships | Tank Barges | Tank Vessels Tankers (Ships & Barges) |
|---|---|---|---|
| Ocean | 246 | 198 | 444 |
| Coastwise | 17 | 127 | 144 |
| Great Lakes | 10 | 17 | 27 |
| Lakes, Bays, Sounds and Rivers | 75 | 2,318 | 2,393 |
| Totals | 348 | 2,660 | 3,008 |

FIGURE 1 - U.S. Tankers - Breakdown by Service, Type, Route, Trade, Size, Cargo, and Age




| | | | | 16,000 - 40,000 DWT | | | | |
|---|---|---|---|---|---|---|---|---|
| Size | 1,000 GT | 1,000 GT-4,000 DWT | 4,000 DWT-16,000 DWT | 16,000 DWT-20,000 DWT | 20,000 DWT-40,000 DWT | | 40,000 DWT-70,000 DWT | >70,000 |
| | Skimmers<br>Harbor refuelers<br>etc. | 9 tankships<br>Special situations<br><br>Replace w/Barges<br>(economics may<br>be other factors) | 0 tankships<br>of this size currently<br>in U.S. fleet | 16-20<br>16 tankships | 20-30<br>75 tank-<br>ships | 30-40<br>60 tank-<br>ships<br>1950-1965 | 31 tankships | 37 tank-<br>ships |
| | | | | WW II<br>T2 & jumboized T2 | | | | |

by water, or by land and water, between points in the United States embraced within the coastwise laws in any other vessel than a vessel built in and documented under the laws of the United States and owned by persons who are citizens of the United States. It restored the cabotage practice which had been waived during the First World War.

Areas covered by the Jones act include the continental United States, Alaska, Hawaii, Guam, Puerto Rico, and certain small island possessions, such as Wake and Midway. The Virgin Islands, Panama Canal Zone, American Samoa, and the Pacific Trust Territories are excluded. The Act also covers merchandise transhipped via a foreign country if the origin and destination are U.S. territory.

2.1.2.1 Present Fleet Utilization

Domestic oil movements may be broken down into crude and products movements:

CRUDE OIL - moved from the area where it is produced to where it is refined:

Alaska to U.S. West and Gulf Coast Ports, Onshore terminal or collection point to refinery, Offshore to onshore.

PETROLEUM PRODUCTS - moved from refinery to where they are used, sometimes in several steps (refinery to distribution terminal, terminal to terminal, terminal to user).

Product movements have a seasonal character to them, i.e., the split among products and the total demand may vary seasonally with more heating oil in the fall and winter and more gasoline in the spring and summer.

There have been traditionally few government regulatory constraints on the flexibility of a U.S. owner to move his U. S. flag tankship from one trade to another. The grade of the cargo for which the vessel is certificated (Grade A, B, C flammable liquids, Grade D, E combustible liquids) - a function of the relative hazard (flash point and vapor pressure) of the cargo is one constraint. The grading system used, however, would allow a vessel to shift from crude oil to gasoline, for example, as long as neither cargo was higher grade (i.e., lower flash-point, higher vapor pressure) than the vessel was certificated for.

A second constraint involves the subsidy status of the vessel. Tankers built with government provided Construction Differential Subsidy (CDS) are not permitted to operate in domestic trade unless they request and receive permission from the Maritime Administration to do so. Such permission can only be granted for a six month period in any year, and the pro-rata share of the subsidy must be returned to the government. Inadequate domestic supply of eligible vessels would also be a necessary basis for permission.

Within these regulatory constraints, owners have traditionally been free to shift tankships between carriage of crude oil and petroleum products and from domestic trade to foreign trade as they saw fit.

While some vessels remain dedicated to one trade, others are shifted from crude to product or foreign to domestic with variations in the demand for transportation services and changing market conditions.

A number of the ships are built as "products" carriers having a large number of tanks and being capable of handling a variety of products at the same time without contamination. Partitioning of ships between crude and product service, however, is rather arbitrary and depends upon what type of movements the owner is able to secure.

In addition to carrying oil, tankships are also used to carry grain since it can be loaded and unloaded through the relatively small oil cargo tank access opening. Grain movement is to a degree counter-cyclical to oil. When rates for oil movement are at their yearly low, grain rates are relatively high.

Another variable in determining present fleet utilization is that U. S. flag tankers operating in the protected domestic trade frequently engage in some foreign to U. S. oil movements during a typical year.

Recently adopted distinctions in tanker safety and pollution prevention requirements between tankships permitted to carry crude oil and those permitted to carry petroleum products will probably reduce somewhat the flexibility to shift between these two categories of cargo. Accordingly the segment of the U. S. flag fleet potentially to be affected was categorized as product or crude carriers as shown on Table 3.

The entire segment of the fleet below 20,000 DWT is basically in the products trade and consists of 25 vessels totalling 309,100 DWT. These vessels are the oldest segment of the U. S. fleet. Twenty-two of the 25 vessels in this size range were built prior to 1956. Five of these tankers were reconstructed in the late 1960's.

## TABLE 3 CATEGORIZATION OF UNSUBSIDIZED U.S. FLAG FLEET TANKERS BY YEAR BUILT

### Crude Carriers

| | 1955 & earlier | 1955-1960 | 1961-1965 | 1966-1970 | 1971-1975 | 1976-1980 | Total |
|---|---|---|---|---|---|---|---|
| 1,000 GRT-20,000 DWT | | | | | | | |
| 20,000 DWT-40,000 DWT | 2 (71,800) | 8 (265,100) | | 6 (225,400) | | | 16 (562,300) |
| 40,000 DWT-70,000 DWT | | 8 (387,100) | 8 (429,500) | 2 (124,100) | 1 (62,000) | | 19 (1,002,700) |
| 70,000 DWT & above | | | 1 (114,700) | 4 (312,700) | 15 (1,398,400) | 16 (2,266,700) | 36 (4,092,500) |

### Product Carriers

| | 1955 & earlier | 1956-1960 | 1961-1965 | 1966-1970 | 1971-1975 | 1976-1980 | Total |
|---|---|---|---|---|---|---|---|
| 1,000 GRT-20,000 DWT | 22 (285,200) | 2 (4,700) | | 1 (192,000) | | | 25 (309,100) |
| 20,000 DWT-40,000 DWT | 60 (1,597,900) | 29 (926,600) | 7 (193,200) | 4 (151,000) | *15 (458,500) | 4 (153,200) | 119 (3,480,400) |
| 40,000 DWT-70,000 DWT | 3 (126,600) | 3 (139,300) | 4 (217,900) | | 1 (41,800) | 1 (42,000) | 12 (567,600) |
| 70,000 DWT & above | | | | 1 (75,600) | | | 1 (75,600) |

*Nine vessels totalling 236,300 DWT chartered to MSC are included in this group.

The majority of product carriers in the Domestic Trade fall in the 20,000-40,000 DWT range. There are 119 product carriers of this size. Over half were built prior to 1956. Forty-two of these were rebuilt at some time in their economic life. Nine vessels in this size range built between 1971 and 1975 are chartered by the Military Sealift Command and technically would not be considered as part of the Domestic Trade fleet; however they would be required to retrofit the potential new design requirements. Two integrated tug barges totalling 73,000 DWT are also included in the 20,000-40,000 DWT fleet. Seventeen of the 136 tankers in this size range have been identified as presently operating as crude carriers. Of the 31 tankers between 40,000 and 70,000 DWT, 19 can be considered crude carriers. Of the remaining 12 in the products trades, three totalling 126,000 DWT were built prior to 1955. However these three were reconstructed in the early 1970's.

There are a total of 37 tankers over 70,000 DWT in the Domestic Trade fleet, 36 of which can be considered crude carriers. One of these, the MANHATTAN, was built in 1962 and rebuilt in 1969. There are also six crude carriers totalling 969,000 DWT scheduled for delivery in 1978; three totalling 478,000 DWT scheduled for delivery in 1979; and one crude carrier of 159.000 DWT scheduled for delivery in 1980. The one tanker over 70,000 DWT which can be considered a product carrier was built in 1970.

2.1.2.2. Future Domestic Oil Movement Demands

In evaluating impacts of various proposed Federal government actions it is important not only to know something about the current tank vessel fleet, but also to have some future estimates or projections concerning the future tank vessel fleet. The size and composition of the future fleet are important factors in estimating the impact of various environmental protection measures. But these same measures may also have an impact on the size and composition of the future fleet. An analysis of supply and demand under various possible regulatory scenarios is presented later in Section 4.3 Economic Impacts. The various factors affecting the change in demand are discussed here.

Generally, domestic ocean shipments by self-propelled tankers stabilized in the 1974-1976 period at about 160 million short tons. Crude oil shipments, however, continued to decline at an average annual rate of about 14 percent, reaching approximately 22 million tons in 1976. With the Trans-Alaska Pipeline System (TAPS) beginning operation in 1977, this pattern was reversed with the addition of about 22 million short tons for this source. This figure will increase substantially as the Alaska Pipeline reaches a flow of 1.2 million B/D. Non-Alaskan related shipments of crude oil are expected to continue to decline, but not be completely eliminated as occasional cargoes will be required for refinery balancing.

The projected effects of Alaskan North Slope crude requirements are outlined in the following section. In general, tanker shipments, other-than-Alaskan-related, are expected to remain constant through 1980, then show a modest growth rate of about 2 percent per year. The demand for Jones Act tankers for trades other than Alaskan is expected to be dominated by petroleum products. The remaining crude oil shipments will probably be made by tankers exceeding 40,000 DWT.

The critical factors in these forecasts are those which indicate a change in level of tanker requirements. The two most important changes each predict a decline in demand. They result from a change in the transportation of Alaskan crude and a growing use of pipelines to carry white products from the Gulf to East Coasts.

1. Alaskan Crude Oil Demand

The trans-Alaska Pipeline System (TAPS) throughput of North Slope (NS) crude oil is approaching its present ceiling of approximately 1.2 million barrels per day. Due to some crude refining constraints on the West Coast over 600,000 barrels per day of the total TAPS throughput will likely be transported to Panama for trans-shipment to the U. S. Gulf and East Coasts through 1980. The calculated tanker requirements for the benchmark years 1978, 1979, 1980, and 1982 are shown on Table 4.

The Balboa, Panama to U. S. Gulf Coast movements are currently made by approximately 750,000 DWT of tankers under 40,000 DWT, about 416,000 DWT in the 40-50,000 DWT class, and about 220,000 DWT of tankers in the 60-90,000 DWT class at reduced drafts. For this assessment, it is assumed that when Alaskan North Slope crude oil movement through the Panama Canal ceases, by 1985, the demand for tankers under 40,000 DWT will be reduced by more than 750,000 DWT as the 40-50,000 DWT class vessels displace smaller ships in other trades. The vessels over 60,000 DWT are expected to serve other markets and not be directly competitive. Thus, the reduction of demand for vessels under 40,000 DWT due to the expected operation of the SOHIO southern tier pipeline and currently unspecified northern tier pipeline by 1985 is projected at 1,166,400 DWT.

2. Gulf Coast East Coast Demand

Transportation of petroleum products from the U. S. Gulf to East Coast has increased substantially in the last decade while waterborne movements have remained relatively constant. To a large extent, pipelines have steadily moved increasing amounts of petroleum products. The two major pipelines currently competing with waterborne movement of petroleum are the Plantation Pipeline and the Colonial Pipeline.

Colonial Pipeline is a relatively new line - opened in 1964 - which consists of twin 36" lines from Port Arthur to Atlanta and a single line decreasing in size from 36" at Atlanta to a 30" segment terminating at Linden, New Jersey.

TABLE 4

TANKER DEMAND FOR ALASKAN CRUDE OIL TRADES
DWT (000)

| Trade | 1978.3 | 1979.1 | 1980.1 | 1980.3[1] | 1982.4 |
|---|---|---|---|---|---|
| **LARGE TANKERS[2]** | | | | | |
| Alaska to | | | | | |
| Alaska | 8 | 9 | 9 | 9 | 10 |
| Puget Sound | | | | | |
| Local Refining | 253 | 258 | 261 | 261 | 272 |
| Northern Pipeline | - | - | - | - | 602 |
| Subtotal | 253 | 258 | 261 | 261 | 874 |
| San Francisco | 711 | 722 | 735 | 735 | 757 |
| Long Beach | | | | | |
| Local Refining | 533 | 463 | 417 | 417 | 497 |
| Sohio Pipeline | - | - | - | 1,211 | 1,575 |
| Subtotal | 533 | 463 | 417 | 1,628 | 2,072 |
| Total West Coast | 1,505 | 1,452 | 1,422 | 2,633 | 3,713 |
| Alaska to Balboa, Panama | 3,101 | 3,201 | 3,251 | 750 | 750 |
| Total Large Tankers | 4,606 | 4,653 | 4,673 | 3,383 | 4,463 |
| **PANMAX TANKERS[3]** | | | | | |
| Balboa, Panama to | | | | | |
| U.S. Gulf(3) | 1,385 | 1,430 | 1,462 | 335 | 335 |

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(1) Assumption: The existence of the SOHIO southern tier pipeline and a northern tier pipeline (either Kitimate or Northern Tier) will preclude the need for movement of North Slope crude through the Panama Canal by 1985.

(2) 100,000 DWT closely approximates the average size tanker participating in the West Coast and Balboa, Panama, movements of Alaskan crude oil. Cargo capacity of such vessels is approximately 94,000 DWT. Large tankers range in size from 70,000 to 265,000 DWT.

(3) The average size of "Panmax" tankers chartered for movements of Alaskan crude oil through the Canal is about 38,000 DWT. The use of these tankers, supplemented with "Swing" at Canal limited drafts, yields an average of 40,000 DWT tanker. Cargo capacity of such vessels is approximately 37,600 DWT. These tankers range in size from 16,500 to 90,000 DWT.

Plantation Pipeline is an older and smaller line, which began operations in 1941. It essentially serves the Sunbelt (Southeastern U.S.) and its norther terminus is in the Washington, D.C. area. Plantation primarily serves the southwestern area, and any increases in its capacity would benefit this area. Assuming Plantation Pipeline expansions displace some level of Colonial traffic to the Sunbelt states the reduction in Colonial throughput or new capacity could be allocated to the more desirable northern markets.

These companies currently represent a total capacity of about 2.5 million barrels per day, of which about 2.4 million B/D is currently being utilized. Current expansion work will add an additional 120 thousand B/D of capacity by 1/1/79, and a further 120 thousand B/D expansion is likely by 1/1/80. Thus, the total capacity available above current utilization levels by 1/1/80 is about 340 thousand B/D. Pipeline Company representatives indicated that expansion beyond this level is possible by looping and increasing the power of existing pumping stations.

Because pipelines are common carriers, the rates must be filed with and approved by the Federal Energy Regulatory Commission. These rates are generally designed to recover system cost on a proportional basis rather than to reflect the marginal cost of any new service. As such, the capital cost of a system improvement is distributed over the entire production. At present, pipelines enjoy a considerable rate advantage over tankers. For example, pipelines rates between the Gulf and the New Jersey area are about $.57 per barrel versus $.99-$1.20 per barrel for tankers. This differential is likely to increase because new tanker construction costs are accelerating faster than pipeline expansion costs.

The present demand for tankers in the U. S. Gulf - East Coast trades can be defined for purposes of this analysis in three basic components as shown below.

Product Flows: Gulf to East Coast By Tanker and Barge
(000 BBL Per Year)

| | 1975 | 1976 | 1977 (Jan. - Oct.) |
|---|---|---|---|
| Petroleum Products to New England (White and Black) | 84,687 | 93,535 | 62,113 |
| White Products to balance of U. S. Atlantic Coast | 292,081 | 302,131 | 272,917 |
| Black Products to balance of U. S. Atlantic Coast | 74,342 | 73,159 | 67,394 |
| Total | 451,110 | 468,825 | 402,424 |

The New England component is expected to remain dependent on tanker or Integrated Tug-Barge (ITB) transportation because standard barges are not cost competitive over such long distances and there is no direct pipeline connection to the Gulf area. The black product to the Atlantic Coast areas south of New England is carried by tankers or barges. Black products cannot be moved via pipeline due to their viscosity and the requirement for heating. This component will be transported by water.

The largest component of the Gulf-East Coast waterborne trade is in white petroleum products destined for ports south of New England. This product movement is also the most vulnerable to pipeline competition. Pipeline flows and tanker/barge movements from the Gulf to East Coast (excluding New England) are compared in the table below:

Transportation of White Product
Gulf-East Coast (excluding New England)
(000 BBL Per Year)

| | 1975 | 1976 | 1977 (Jan. - Oct.) |
|---|---|---|---|
| Tanker/Barge | 292,081 | 302,131 | 272,917 |
| Pipeline | 597,534 | 661,883 | 571,527 |

The tanker/barge movement is split nearly equally. The near-term pipeline expansions will probably absorb a very substantial portion of the current waterborne movement due to the economic advantage of the pipeline. Current and Projected Capacity can be seen from the table below:

(Million B/D)

| Tanker/Barge[1] | | Current Pipeline Deliveries | | Projected Addition to Pipeline Company[2] | |
|---|---|---|---|---|---|
| 1975 | 1976 | 1975 | 1976 | 1975 | 1976 |
| .800 | .828 | 1.64 | 1.81 | .12-.32 | .24-.44 |

[1] Tanker and barge portions each represent roughly half of total movement at present.

[2] Reflects currently projected expansion and maximum utilization of excess capacity.

Based on the expected pipeline expansion and the existing pipeline-favoring rate differentials, pipelines can be expected to absorb much of the product currently carried by tankers from the Gulf to the Atlantic Coast destinations south of New England. This will reduce the long-term demand for Jones Act tankers under 40,000 DWT by approximately 550,000 DWT, or about 30 vessels.

3. Strategic Petroleum Reserve

Current projections for the fill of the Strategic Petroleum Reserve (SPR) indicate that 250 million barrels will be in place by the middle of 1979 and that the ultimate goal of one billion barrels will be achieved by December 1985. It should be noted the SPR fill is not a Jones Act trade, and the proposed enhancement of safety and pollution requirements will not impact on vessels operating in this trade. Further, it is not mandated that this cargo must be carried on U.S.-flag ships (only 50 percent must be carried on U.S.-flag vessels if such vessels are available at fair and reasonable rates).

Thus, while this trade is not directly applicable to the analysis of demand for unsubsidized tankers in the Jones Act trades, the SPR fill demand is critically important in the transitional period during which the revised safety and pollution regulations become effective. This is because it can serve as a buffer into which tanker capacity made surplus by reductions in the Alaskan crude and Gulf Coast - East Coast tanker requirements can be absorbed. Further, because the SPR fill tankers would not be subject to the possibly more stringent Jones Act standards, they may enjoy a rate advantage over that capacity which has been upgraded either by conversion or replacement. As such, the SPR fill program is thus treated as a reserve source of employment for unsubsidized tankers.

4. Outer Continental Shelf (OCS)

Another area of concern in predicting future oil movements is what role tankships and tank barges may play in moving oil produced on the OCS from offshore to refineries or from pipeline terminals or collection points to refineries. Movement of oil from OCS production to shore would be considered "domestic trade" under existing laws and regulations.

It is very difficult, however, to project at this time the amount of oil to be found and transported. A quantitative definition of the problem of oil pollution from OCS tanker operations and accidents is thus not possible. Nevertheless, this problem will be treated qualitatively in sections 2.3 Possible Hazards (oil outflows from OCS oil), 3. ALTERNATIVE PREVENTATIVE ACTIONS, and 4. EVALUATION OF ALTERNATIVE PREVENTATIVE MEASURES.

## Estimated 1985 Demand Level

The existing fleet of small domestic tankers is fully employed during the peak season of the domestic oil trade. We were not able to identify any measurable quantity engaged in other trades during the peak season. Therefore, we included the entire existing fleet, less the very small tank ships and ships on long term MSC charter, in current peak season demand. We realize that ignoring possible employment in other than the domestic oil trade results in a maximum level estimate for demand.

For 1985 demand, we apply the two deductions to 1978 demand to account for predicted development of pipeline alternatives. The development of one or more crude oil pipelines from the West Coast to mid-continental refineries is expected to eliminate the need for small tankers currently used in the trans-Panama route for Alaskan oil. We expect that product pipelines between the Gulf states and the mid-Atlantic states will expand their capacities in response to cost and financial advantages over tank ships.

Other pending developments in the U. S. oil distribution system were considered but not included in our forecasting. Unless there are unforeseeable changes in the locations and capacities of U. S. refineries, developments such as offshore deepwater ports would not significantly affect the patterns of domestic tankers trade. Substitution of tank barges for self-propelled ships could have a significant effect, but there are no recognizable trends from which we could forecast such substitutions.

The following table presents the numerical levels of the process described in the preceding pragraphs:

All ships are less than 40,000 DWT.

| DWT (000) | |
|---|---|
| 4,351.8 | total small domestic fleet |
| 21.7 | deduct very small ships |
| 385.5 | deduct long term MSC charters |
| 3,944.6 | 1978 Jones Act fleet (fully employed) |
| 1,166.4 | deduct for crude pipelines |
| 550.0 | deduct for product pipelines |
| 2,228.2 | FORECAST 1985 DOMESTIC DEMAND |

2.1.3 Employment of Tankers

Tankships may be divided into two basic groups according to their ownership:

(1) those owned by oil companies

(2) those owned by other independent companies and offered for charter

The oil companies have company fleets to carry a percentage of their oil movement requirements and charter tankers from independents on both a long and short term basis to carry the remaining portion of their movements. The oil company fleets thus are less subject to the risk involved in market variations with time.

A further breakdown of the U. S. flag tanker fleet by owner types is presented in Appendix E of this report in determining the economic impacts of potential regulatory requirements.

A concern regarding ownership is the impact on vessels under charter of the retrofit type of pollution abatement requirements. A further description of charter arrangements is offered in this section for this reason.

A charter party is a contract by which the charterer (one other than the shipowner) obtains the use and service of all or some part of a ship for a period of time or for one voyage or several voyages. There are three types of charters - voyage, time, and demise (or bareboat). Voyage charters are what their name implies, carriage from one place to another. Time charters provide for the use of the vessel for an agreed time (often twenty years or more). In these types, the shipowner retains possession and control of the vessel. A demise (or bareboat) charter is similar to the time charter except that the charterer takes full possession and control of the vessel. Rights and liabilities of the shipowner and charterer depend upon the type of charter.

A bill of affreightment is a contract for carriage of goods. American courts often refer to a bill of affreightment as a time charter. Since they are so similar, they will be treated the same for the purpose of this discussion.

Time and demise charters are contracts and contain several clauses. Some are considered warranties, the breach of which would be grounds for cancellation of the charter party. The clauses relevant to the retrofit issue are capacity, off-hire, and excepted perils. Frustration is also a concept that is relevant.

Capacity is often considered a warranty clause. Capacity may be specified as total deadweight tonnage or a cargo carrying capacity. If the vessel delivered has less capacity than the contract calls for, cancellation of the charter party may be allowed. This situation normally occurs when the vessel is first tendered and the charterer exercises his option to cancel the charter party before the term of the charter begins. The question of the reduced capacity after the term of the charter party has begun is not thought to have been addressed yet in the courts. If the reduction in capacity from retrofit is substantial, a court might permit cancellation.

If cancellation of a charter party is to be allowed, the most likely basis will be the capacity clause. However, there is no way to predict what a court will do in a particular case.

Many charter parties contain clauses that allocate certain risks to one party or the other, and require compliance with all laws and regulations and treaties. If a charter party contains a clause like this, then retrofit would not be grounds for cancellation. Financing charters reviewed by the Maritime Administration provide for adjustment of the payment if any governing body requires changes to the ship.

In the United States it seems that the market place would make any adjustments necessary to the charter parties. Many modern charter parties contain clauses that would take care of these contingencies. Legislation to protect participants in a charter party from loss due to government regulation would most likely be very low priority on the legislative calendar. In addition, the Senate did not provide an adjustment in its retrofit requirement in S. 682. Instead, the Senate was ready to penalize shipowners who did not retrofit early, through a retrofit incentive fee.

### 2.1.4 Legal Framework

This section reviews some of the available legal framework and the need for changes in order to implement the potential regulatory packages identified in this report.

#### 2.1.4.1 Authority To Impose Requirements On Vessels

The study evaluated a number of measures that could be applied to U.S. tank vessels engaged in the coastwise trade. The coastwise trade, (hereinafter referred to as "domestic trade") generally speaking is trade between ports or places in the United States and is limited to vessels built in the United States and owned by United States citizens. See 46 U.S.C. 833. The study focused on U.S. domestic trade vessels because about 200 of these vessels would not be affected by some of the construction and equipment standards adopted by the ISPP Conference.

Pursuant to the Tank Vessel Act (TVA), R.S. 4417a, 46 U.S.C. 391a, the Coast Guard has authority to regulate, among other things, the design, construction, manning and equipment of tank vessels -- U.S. flag vessels wherever they may be and foreign flag vessels when they operate in the navigable waters of the United States, subject to international law and treaty commitments. In addition, the Coast Guard may establish navigation requirements (such as vessel traffic services) for all vessels operating in the navigable waters of the United States. Title I of the Ports and Waterways Safety Act of 1972 (PWSA), 33 U.S.C. 1221 et seq.

In promulgating regulations, the Coast Guard cannot act arbitrarily or capriciously. Any time an agency establishes a sub-class within a class for regulatory purposes, there must be a "rational basis" for the distinction. Here the historical class has been all vessels of the same type operating in the same waters. In this study, the sub-class under consideration is U.S. flag vessels engaged in the domestic trade.

The primary focus of the study related to matters (such as segregated ballast and inert gas systems) which fall within the purview of the TVA. With respect to these measures, the Coast Guard and DOT have in the past concluded that no distinction in treatment can be made between U.S. tank vessels engaged in the domestic trade and U.S. tank vessels engaged in the foreign trade. See 39 Fed. Reg. 24151 (28 June 1974); 40 Fed. Reg. 48281 (14 October 1974); 41 Fed. Reg. 15859 (15 April 1972); 41 Fed. Reg. 54177 (13 December 1977); DOT letter dated 27 June 1974 to the Under Secretary of the Department of Interior; and Coast Guard Commandant letter dated 26 May 1967 to Senator Magnuson. 1/

The documents cited in the paragraph above discuss the rationale for the existing DOT and Coast Guard position. The most significant fact is that since enactment of the original TVA in 1936 (49 Stat. 1889) the agencies charged with administering the law (initially the Bureau of Marine Inspection and Navigation, and then the Coast Guard) have never created a distinction between domestic and foreign trade in the application of design, construction and equipment requirements. In 1972, the TVA was amended to require express regulations to protect the marine environment (the 1936 Act was directed to safety and environmental protection was only an incident of safety regulation). At that time, a new international effort aimed specifically at marine pollution from tank vessels was being undertaken. Congress recognized that precipitous action on its part might endanger fruitful negotiations and therefore provided in the law that the effective date for regulations for the protection of the marine environment should be delayed. (Subsection (7)(C) of the TVA.) In addition, there was fear that if requirements were imposed only on U.S. flag tank vessels and not on their foreign flag counterparts the U.S. merchant marine would not be able to complete

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1/ The legal determination reflected in these documents is also asserted in the litigation styled NRDC v. Adams (Secretary Adams was substituted for Secretary Coleman) Civ. No. 76-0181 filed 2 Feb. 1976 (D.C. D.C.) This litigation is inactive pending action by the Coast Guard and DOT subsequent to the Tanker Safety and Pollution Prevention Conference.

effectively. Therefore, Congress provided that any rule or regulation for the protection of the marine environment "shall be equally applicable to foreign vessels and United States flag vessels operating in the foreign trade." Section (7)(D). From the above, the Coast Guard and the DOT concluded that "(s)ince there was no provision in 46 U.S.C. 391a authorizing any distinction in treatment between U.S. vessels engaged in the domestic trade, nor any provision authorizing any distinction in treatment between U.S. vessels and foreign vessels, it is clear that the intent of the Congress in subsection 7(D) was to assure in the implementation of subsection 7(C) that no distinction in treatment between U.S. and foreign vessels be inferred from any treaty, convention, or international agreement." 39 Fed. Reg. at 24151.

The opposing position was represented by the Department of Interior. Interior contended that DOT's reliance on subsection (7)(D) was misplaced because the Senate Report (No. 92-724) to the TVA amendments of 1972 made clear that the prohibition in distinction between U.S. vessels in foreign trade and foreign flag vessels did not apply to U.S. vessels engaged in the domestic trade in which competition from foreign flag vessels is precluded by law (7 June 1974 letter from the Under Secretary of the Department of Interior to the Under Secretary of Department of Transportation.) This interpretation was supported as well by members of Congress. (See letter of 23 September 1974 from Representative Dingell to Secretary Brinegar and letter of 17 September 1974 from Senator Muskie to Secretary Brinegar) Senator Muskie in his letter noted "[i]t has always been my understanding that the Coast Guard could, if it so determined, establish standards for vessels engaged in such trade [domestic trade] different from standards applicable to vessels engaged in international trade . . . Congress was well aware of the differences between domestic and international trade and, in drafting Section 7(D) of the Act . . . it clearly left open the possibility that different standards could be established for domestic trade where U.S. vessels are protected by law from foreign competition." On 16 June 1978, the NOAA General Counsel issued a Memorandum of Law that further explains and supports the arguments contrary to the Coast Guard and DOT position.

Against this background, the following analysis should be undertaken in implementing any decisions flowing from recommendations in this report relating to vessel design, construction and equipment requirements:

a. Implement the decisions as much as possible under the authority of Title I of the Ports and Waterways Safety Act or other applicable authority.

b. Review the authority under the TVA for distinguishing between U.S. flag vessels operating in different trades.

c. Consider legislation specifically authorizing a distinction in treatment between U.S. flag vessels operating in the foreign trade from U.S. flag vessels operating in the domestic trade, taking into account that U.S. flag vessels entitled to engage in the domestic trade may freely operate in the foreign trade, and that design and construction requirements may not be able to be changed from voyage to voyage.

## 2.2 DEFINITION OF THE ENVIRONMENT

This report examines U.S. flag tankers in the domestic trade and the impact that certain proposed pollution abatement requirements will have upon the environment. The environment in this instance is bounded by the definition of "domestic trade." Domestic trade means trade between ports or places within the United States, its territories and possessions, either directly or via a foreign port including trade on the navigable rivers, lakes, and inland waters (33 CFR 157.03(2)). The environment then is any waters that could be used by the subject fleet in its operation. The waters are harbors, ports, estuaries, coastal waters and oceans.

The exact extent of the environment cannot be specifically bounded; there is no simple geographical boundary. The landward limit is particularly variable; the influence of the sea may extend as far as the upper reaches of tidal creeks and rivers. The seaward limit of this environment may be easier to define; e.g., the edge of the continental shelf, where the water depth changes rapidly and open ocean begins. One measure of the extent of the coastal environment is that more than one half of the population of the country lives within a 1-hour drive from a major coastline.

The environment, in addition to use for navigation by tankers and other vessels, is used for valuable commercial fishing grounds, recreational facilities, and habitats for many types of marine life. The value of the environment sometimes can be expressed in monetary terms, such as fishing grounds or boating facilities. On the other hand, the value of the scenic beauty of the seashores and surf cannot be measured.

The Council on Environmental Quality reports that "even in a natural, uncultivated state, estuaries support two-thirds of the fish species in the Atlantic and Gulf of Mexico,".

## 2.3 POSSIBLE HAZARDS AND UNDESIRABLE EVENTS

If corrective actions are to be effective, it is important that the hazards or undesirable events which potential corrective actions are intended to eliminate or control be identified and clearly defined. To do this, this section is intended to explore answers to the following questions:

What losses are we trying to prevent?

What evidence do we have that these losses are occurring?

What role do tankers, particularly U.S. tankers in domestic trade, play in causing these losses?

2.3.1 What Losses Are We Trying To Prevent?

Tanker safety and pollution prevention measures are aimed at eliminating or controlling the following categories of losses:

1. Deaths to persons (crew, passengers, workers, general public)

2. Injuries to persons (crew, passengers, workers, general public)

3. Damage to property

   a. vessels

   b. cargoes

   c. facilities (piers, wharves, terminals, etc.)

4. Damage to the marine environment

   a. water pollution by oil [1/]

      effects on habitats

      effects on aquatic organisms

         populations

         communities

         loss of fisheries resources

      effects on seabirds

      direct impact on humans

         tar and oil on beaches

         loss of recreational fishing days

         possible human health effects

         fouling of boats, docks, sea walls, fishing gear

   b. air pollution

      release of hydrocarbon vapors during routine operations in areas where air quality is already a problem

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1/ Short-term and long-term loss categories resulting from oil discharge to the water are outlined in detail in Section IV of Appendix D.

release of combustion products and oil droplets as a result of fire following an accident

5. Loss of function (this is really a transportation system inefficency)

   a. vessel cannot proceed with voyage

   b. operation cannot proceed (delay in transfer of cargo, oil production, etc.)

2.3.2 What Evidence Do We Have That These Losses Are Occurring And What Role Do Tankers, And Particularly U.S. Tankers In Domestic Trade, Play In Causing These Losses?

Losses in the first three categories above -- deaths, injuries, and property damage -- are documented in the Coast Guard's Vessel Casualty Report files. Accidents involving U.S. tankers in domestic trade result in about four deaths and seven serious injuries each year, primarily to personnel on the vessel. Occasional incidents, primarily fires and explosions, result in deaths and injuries to crews of other vessels, terminal personnel, or members of the public at large.

Between 1963 and 1975 there were 27 fires or explosions involving liquid cargo on U.S. flag tank ships. Eleven of those incidents resulted in 65 deaths. The single largest casualty was the V. A. FOGG in which 39 people died when the vessel exploded and sank during tank cleaning. On other U.S. flag tank ships, there were pump room explosions which accounted for 11 deaths and 6 deaths were the result of magnesium anodes falling within a tank and causing ignition. IGS would not have prevented the pump room explosions. It could have prevented the explosions due to falling magnesium anodes, but alternative and equally effective measures were adopted instead to prevent recurrence.

Losses in the fourth category -- damage to the marine environment -- are indicated by:

- o presence of tar and oil on beaches
- o reports of oil spill damage (ARGO MERCHANT, METULA, AMOCO CADIZ, Barge FLORIDA, and others)
- o reports of spill cleanup costs

For purposes of this study, losses involving damage to the marine environment are of primary concern and these are analyzed in detail in Appendix C. Table 5 (reproduced from Appendix C) represents the two most important ways U.S. tankers in domestic trade contribute to damage to the marine environment. The situation may be summarized as follows:

Oil is being discharged to the marine environment by U.S. tankers in domestic trade, most importantly as outlined in Table 5.

These discharges are having some environmental effects.

Some discharge restrictions and control methods have been established in an attempt to control oil discharge, and therefore environmental damage, from these vessels. Some of these are already in use; others are in various stages of implementation.

But, are these restrictions and methods effective enough? Do they provide adequate protection? Can they be made effective enough (with time and additional enforcement and educational efforts, for example) or is some additional action required?

Should we, for example, try to eliminate at least part of these inputs through requiring additional construction and equipment measures such as SBT or CBT?

In order to answer these questions, answers to the following questions need to be developed:

How much oil is currently being discharged to the marine environment from the sources in Table 5?

What environmental effects are these discharges having?

What discharge restrictions and control methods are currently in use? How effective are they? How might they be made more effective? What evidence exists that current control methods are less than adequate?

Table 6 and Figure 3 (reproduced from Appendix C) present estimated oil inputs from accidents and operations of U.S. tankships, 5000 DWT - 40,000 DWT, in domestic trade in 1985. Details of these estimates are included in Appendix C. It must be emphasi ed that because this relates to vessels in the U. S. domestic trade, resultant pollution is concentrated off U. S. shores.

Table 5
Hazard scenarios of particular interest--U. S. tankships in domestic trade

| VESSEL (Table 2) | EVENT (Table 3) | LOCATION (Table 4) |
|---|---|---|
| Tankships, Ocean routes, 5,000-40,000 DWT Product carriers (119 vessels) | Collision, ramming, grounding accidents | Coastal waters, harbor and harbor entranceway |
| | Cargo oil discharges as a result of routine operations--see Table 3a for specifics | U. S. coastal waters, but not limited to 50 miles offshore |
| Tankships Ocean routes 5,000-40,000 DWT Crude carriers transporting OCS oil to shore | Collision, ramming, grounding accidents | Coastal waters, harbor and harbor entranceway |
| | Cargo oil discharges as a result of routine operations--see Table 3a for specifics | U. S. coastal waters, but not limited to 50 miles offshore |

Table 6

Estimated oil inputs from accidents and operations of U.S. tankships, 5,000 DWT - 40,000 DWT, in domestic trade, 1985

| Source | Estimated oil inputs metric tons/year | |
|---|---|---|
| Accidental inputs | | |
| Collisions and rammings | 9 incidents / 650 tons | |
| Groundings | 6 incidents / 640 tons | |
| | "good" practice | "bad" practice |
| Operational | | |
| "white" product | 3,680 | 39,930 |
| "black" product | 920 | 44,160 |
| Total oil inputs | 5,890 | 85,380 |

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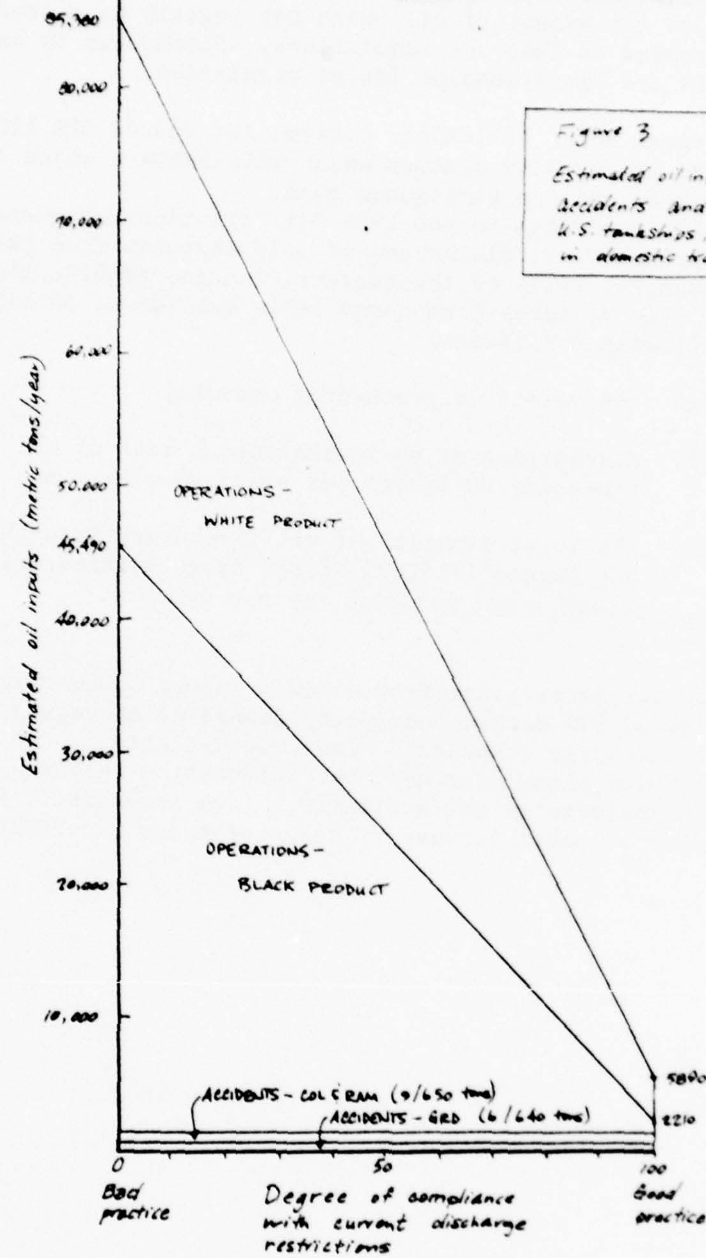


Figure 3

Estimated oil inputs from accidents and operations U.S. tankships, 5,000–40,000 DWT in domestic trade, 1985

A key variable in this assessment is the uncertainty over the degree of compliance with current operational discharge restrictions. Limitations on the amount of oil which may legally be discharged are found in a number of laws and regulations. Discharges in excess of these amounts are violations of law or regulation.

The Federal Water Pollution Control Act and 40 CFR 110 prohibit the discharge of any oily mixture which will leave a sheen into U. S. navigable waters and the contiguous zone.

The 1969 Amendments to the 1954 Oil Pollution Convention and 33 CFR 157 prohibit all discharges of oily mixtures from cargo tanks within 50 nautical miles of the nearest land and require that vessels discharging oily mixtures from cargo tanks outside of 50 miles comply with the following conditions:

(1) the vessel is proceeding enroute,

(2) discharging at an instantaneous rate of oil content not exceeding 60 liters per nautical mile, and

(3) the total quantity of oil discharged into the sea does not exceed 1/15,000 of the cargo carried for existing vessels and 1/30,000 for new vessels.[1]

Outflow estimates range from a low of about 6,000 metric tons/year to as high as 80,000 metric tons/year, depending on degree of compliance with operational discharge standards. The true situation today probably lies somewhere between these extremes, but information on which to base a more precise estimate is not available. (See Appendix C, P C-19 and C-20 for discussion of possible ways of reducing these uncertainties.)

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[1]The requirement of 1/30,000 for new ships resulted from the 1973 MARPOL Convention.

### 2.3.3 Environmental Effects of Oil Discharges From U. S. Tankships in Domestic Trade

The environmental effects of accidental oil spills from tank ships should be considered separately from the effects of routine low-level operational discharges from tank ships (such as those from deballasting and tank washing).

Accidental Spills

The accidental spills from U. S. tank ships in domestic trade have occurred overwhelmingly in harbor and port areas in the few recent years for which we have pollution incident data (Appendix C). Both in numbers of incidents and in amounts of oil outflow, the great preponderance of spills is at the coastal edge, near centers of human population, and in areas which are likely to involve multiple uses and rich biological communities.[1] It appears likely that spills resulting from collision, ramming, and grounding accidents will continue to occur nearshore, where waters are shallow and ship traffic is relatively heavy.

No effort has been undertaken either in the past or as part of this study to ascribe particular environmental harm to spills from U. S. tankers in the domestic trade, although considerable information is probably available if it were collected and collated. In the absence of information to the contrary, it seems reasonable to assume that the damage from oil spills in general can be attributed pro rata to spills from these vessels.

The effect of an accidental spill depends upon the amount spilled; the open or confined nature of the spill site; the type of oil spilled; wind, wave and current conditions; the turbidity of the water; the season; and the biological environs in terms of habitat and population.[2]

The spills reported in Appendix C are quite small. Given the size of the spills, effects were probably localized, ranging from a few miles to tens of miles. However, because they occurred in harbor and port areas they are likely to have been confined, concentrated and relatively toxic. Damage tends to be greater where spills are confined naturally or artificially to a limited area of shallow water for several days. For a given quantity of oil, the more localized the distribution of the spill, the greater the mortality tends to be.[3] Spills in harbors and ports are likely to be fresh and thus more toxic in their effect on marine organisms.[4]

[1] It might also be argued that spills in environmentally degraded harbors have less impact than those affecting undeveloped estuarine waters.

[2] National Academy of Sciences, Petroleum in the Marine Environment (hereafter NAS) at pp. 83-85 (1975).

[3] NAS at p. 98.

[4] Katherine Gillman, Oil and Gas in Coastal Lands and Waters (hereafter Gillman) at p. 9 (1977).

The environmental effects differ in turn depending on the type of oil spilled and the organisms encountered. The bulk of the products involved in the U. S. domestic trade is in the refined, light oils or "white products" -- gasoline, kerosene, diesel fuel and the like. These oils seem to disappear rapidly on the sea. A part of the oil goes into solution, becomes dispersed in the water column and is thereby actually more readily available to marine organisms than if it were floating on the surface. The more soluble components are generally the more toxic ones and may present a more serious threat to marine life than crude oil. The white products are definitely more toxic than "black products" such as No. 6 residual fuel oil.[5]

While most data on mortality to seabirds have been gathered from spills of crude and heavy fuel oils, expected mortality would be as severe, or more so, should seabirds encounter light oils. These oils can damage birds' down, which insulate them from cold and wet, in the same way as heavier oils, and the light oils are more toxic when ingested or absorbed through the skin. Limited information is available on spills of light oil, but a rather small spill (640 metric tons) of No. 2 diesel oil into Puget Sound in 1971 killed some 30,000 Brant which represented about 25 percent of the entire population of this species in the Pacific Flyway of North America. Within two days following the sighting of a slick of light diesel oil off the west coast of Alaska in 1971, 86,000 birds died.[6]

Seabirds, particularly those which dive, have been the most notorious victims of spills of crude and other black products. Oil spills near-shore in harbor or port areas seriously threaten waterfowl in these habitats. Birds flocking together for feeding or other social reasons are especially vulnerable to localized spills. In addition to mortality of individuals, bird populations make a slow and uncertain recovery from oil-caused losses because they reproduce few at a time, relatively infrequently.[7]

Rich estuarine wetland and marsh habitats are likely to be affected by U. S. domestic tanker oil spills, whether of black or white products. Benthic organisms and their habitat are particularly susceptible. These bottom dwellers--lobsters, oysters, clams and scallops--are important fisheries resources. They can become coated with heavy oil and smothered. As filter feeders, they also ingest oil present in water.

A diesel oil spill off the coast of California killed clams and abalone as well as practically all other animals inhabiting the cove at the time of the spill. The recovery of many species occurred during the next few years, but abalone were still absent after sixteen years and many species were not as abundant as before the spill.[8] Similarly, the West Falmouth, Massachusetts spill of No. 2 diesel fuel oil wiped out whole populations of shellfish in 1969. Four years later, though the harbor and marsh were recolonized, the shellfish were still too contaminated to eat.[9]

[5]Food and Agriculture Organization of the United Nations, Impacts of Oil on the Marine Environment (hereafter FAO) at p. 55 (1977).

[6]FAO at p. 57

[7]Gillman at p. 13.

[8]FAO at p. 63.

[9]Gillman at p. 12.

A wide variety of benthic invertebrates was killed by diesel oil spilled into Puget Sound in 1971, with mortalities for forty-eight species of intertidal invertebrates ranging from 30 to 100 percent.[10]. Larvae and juvenile forms of benthic organisms are particularly vulnerable to spilled oil and if the spill occurs during breeding or spawning, losses will increase.[11]

The fin fish resources in such nearshore areas may also be affected by spills. While adult fish are apparently able to avoid spilled floating oil, they may be affected by oil entering the food chain. Spills in near-shore spawning grounds or breeding areas could potentially decimate an entire generation. Fish eggs and larvae are susceptible to oil damage as they float on or near the surface of the sea.[12] There is some evidence that light refined oils have a more serious impact on pelagic fish than crude or black products.[13]

Less dramatic effects of spills involve the phytoplankton, the "grass of the sea," and the zooplankton, minute animals near the bottom of the food chain. Refined and crude oils in concentrations from 60 to 200 parts per billion hamper photosynthesis in phytoplankton and affect behavior in zooplankton.[14] Individual local spills are not as serious a threat to the plankton as increasing concentrations of oil in the sea over the long term; the chronic pollution by oil which is in part caused by spills in heavily trafficked harbors may have devastating, as yet unpredictable, impacts on marine biota from the least to most complex.

Spilled oil of the heavier types, when deposited, may render areas uninhabitable to plants and animals. Persistent crude oil or black products may cause major harm in estuarine areas. Oil deposited in fine sediments can remain physically and chemically insulting to the environment from four to ten or more years, although in rocky areas such oil may be naturally scoured in as little as two years.[15] The presence of such oil also renders the coastal area unusable, or far less attractive, for human activity. Restoration of a contaminated area, while perhaps recapturing it for recreation, may cause long-lasting changes to the biological community.

[10] FAO at p. 69.

[11] Symposium, Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment (hereafter Symposium) at p. 480 (1976).

[12] Gillman at pp. 13-14.

[13] FAO at p. 59.

[14] Gillman at p. 10.

[15] Massachusetts Institute of Technology, Potential Biological of Hypothetical Oil Discharges in the Atlantic Coast and Gulf of Alaska (hereafter COM-74-11089) at p. 5 (1974).

While it cannot be demonstrated that accidental spills from U. S. tankers in domestic trade (or from any tankers) place coastal waters near or beyond their threshold for eventual safe absorption and dilution of petroleum hydrocarbons, oil spills do contribute to mortality and/or alteration of behavior in marine organisms and degradation of nearshore human recreation and habitation resources in the short term. In the long term, the accumulated effects of such spills are unknown.

Oil spills in the coastal waters indisputably harm the quality of beaches and recreational waters. The resort industry in an affected area is likely to suffer. Likewise, even small oil spills from domestic trade tankers may prohibit fishing for periods of time due to dangers of fouling gear. The dimenstions of harm from small spills is illustrated by the results of the collision in January 1971 of two 17,000 DWT tankers just west of the Golden Gate Bridge in San Francisco Bay. The resulting spill from one of these small, World War II vintage tankers was 2,600 tons, enough to pollute beaches 20 to 25 miles away. The clean up effort required 350 hired workers and hundreds more volunteers.[16] Further discussion and estimates of the economic impact of such spills on human activity appear in Appendix D.

## Operational Discharges

The great bulk of oil outflow from the U. S. tanker fleet in domestic trade originates in operational discharges. The environmental effects of these discharges is much less observable than those from nearshore spills. Operational discharges, if carried out in compliance with all applicable regulations, are dilute and occur at a distance of at least 50 miles from land. Assessing the environmental effects of oil discharges far from land is difficult, and straining to assess the impact of discharges from a subset of tankers when definitive information on the routes followed by these tankers is lacking, compounds the difficulties. The discussion below should be viewed as preliminary only.

Petroleum residues have been reported to be found widely dispersed over the surface of the ocean in concentrations roughly proportional to tanker traffic.[17] Analysis of these floating residues seems to indicate the weathered oil may be derived primarily from tanker discharges.[18] These residues are frequently deposited on beaches, and it seems likely that some tar balls on U. S. shores are caused by discharges from domestic tankers carrying black products as well as from discharges by other ships. It seems unlikely that U. S. tankers in domestic trade carrying white products are contributing to this particular impact on the environment.

[16] Gillman at p. 54.

[17] Proceedings: 1977 Oil Spill Conference (hereafter Proceedings) at p. 499 (1977).

[18] NAS at p. 49.

The pollution of beaches and nearshore waters by weathered tar has a continuing serious, but so far unquantified impact on recreation. (For example, observers report that tar on Atlantic beaches from the Carolinas south to Miami Beach is distinctly increasing, but quantitative studies of amounts, trends and estimated dollar costs to the recreation industry are lacking.) The other impacts of continuous oil discharges on the marine environment, particularly on the production cycle in the sea, are not yet clear, but are being studied.[19]

Portions of petroleum discharged at sea appear to evaporate and decompose in the atmosphere. Other portions oxidize by chemical and biological means to $CO_2$. The heavier fraction forms pelagic tar; some protion of this remaining material must ultimately be sedimented in the open ocean and in coastal areas. Incorporation into coastal sediments may have particularly important, if ill understood, long term impact.[20]

Repeated low level discharges of oil at sea, if not evaporated, decomposed, oxidized or incorporated into sediments, are likely to remain dispersed in the water column available to marine organisms, with unknown results.[21] Likewise little is understood about the effect of the concentration of trace materials in slicks. Oil slides act as accumulators of metal ions, vitamins, DDT residues and PCB. These accumulations may substantially affect life on or near the sea surface.[22]

While catastrophic effects cannot be predicted in the offshore ocean environment where operational discharges from the U. S. tankers legally occur, there is considerable concern for the surface dwelling neuston. These communities which include jellyfish, algae, and other organisms are particulary vulnerable to contact with either a floating slick or tar balls. The ecological role and importance of the neuston communities and the harm from the disruption of the communities cannot be currently assessed.[23]

Because both oil slicks and tar balls resulting from operational discharges are concentrated in the tanker traffic routes, the severity of the impact of the discharges from the U. S. tankers here under study can only inferentially be gauged. No accurate attribution on a vessel-by-vessel basis is possible. A share of the harm done is done by U. S. tankers in the domestic trade, and the share may even be disproportionate because these tankers tend to operate more in coastal waters.

[19] Marine Resources Monitoring, Assessment and Prediction Red Flag Report No. 1, Fish Larvae Found in Environment contaminated with Oil and Plastic, at p. 1 (1973).

[20] NAS at p. 105.

[21] NAS at p. 55; Symposium, at pp. 288-292.

[22] NAS at p. 53.

[23] Symposium, at pp. 471-472, 475.

Perhaps the conclusions reached by the National Academy of Sciences 1975 study provide the best overall view of the situation which appears to be still valid today:

> In general, much more research regarding the fates and effects of petroleum hydrocarbons in the marine environment is needed. We know that the quantity of floating tar in the open ocean and of tar along coastlines has been increasing, that major spills and localized continuous discharges of petroleum hydrocarbons have damaged various species of marine life, and that low levels of petroleum may affect the behavior patterns of certain species. Studies to date indicate that areas polluted with petroleum hydrocarbons "recover" within weeks or years (depending on local conditions and the characteristics of the petroleum); however, composition of the local biological communities may be altered. The oceans have considerable ability to purify themselves by biological and chemical actions. A basic question that remains unanswered is, "At what level of petroleum hydrocarbon input to the ocean might we find irreversible damage occurring?" The sea is an enormously complex system about which our knowledge is very imperfect. The ocean may be able to accommodate petroleum hydrocarbon inputs far above those occurring today. On the other hand, the damage level may be within an order of magnitude of present inputs to the sea. Until we can come closer to answering this basic question, it seems wisest to continue our efforts in the international control of inputs and to push forward research to reduce our current level of uncertainty.

## 3. ALTERNATIVE PREVENTIVE ACTIONS

The objective of this portion of the study is to identify alternative preventive actions to either eliminate or control each of the hazards and events identified in Section 2.3.3. Alternative preventative actions to be considered may be divided into the following categories:

1. Actions Relating to Vessel Construction and Equipment
2. Actions Relating to Improvements of Crew Standards and Training
3. Actions Relating to Reception Facilities for Oily Wastes
4. "Specific Trade" and "Special Ballast" Arrangements
5. Actions Relating to the Waterway and Operating Rules
6. Actions Relating to Enforcement Efforts
7. Actions Relating to Economic Responsibility

### 3.1 ACTIONS RELATING TO VESSEL CONSTRUCTION AND EQUIPMENT

Much of the original impetus for this study arose out of concern over the possible need for additional construction and equipment measures for U.S. tankers in domestic trade, so most of the study group's effort was devoted to examining measures in this category. Crude carriers are not addressed because by 1985, there is expected to be almost no demand for such ships within the scope of this study. The following preventive action was considered in detail:

- o extension of the requirements of the 1978 Protocols to SOLAS 74 and MARPOL 73 (commonly referred to as "TSPP requirements") down to smaller tankships, and
- o application of requirements originally contained in the Presidential Initiatives to smaller tankships.

The present lower limits of application of various measures included in TSPP requirements are shown in Table 1 on page 2. With regard to product carriers the most significant differences between TSPP Conference results and measures originally proposed by the U.S. are: For new product tankships, the lower limit for protective location and segregated ballast tank requirements is 30,000 DWT instead of 20,000 DWT. For existing product tankships, the lower limit for CBT or SBT and for IGS is 40,000 DWT instead of 20,000 DWT.

#### 3.1.1 Tonnage Limits

The Presidential Initiatives set 20,000 DWT as the lower limit for tankship construction and equipment requirements. This 20,000 DWT figure was recommended by the Interagency Oil Pollution Task Force, largely on the basis of previous use of this figure.

In preparation for the 1973 Marine Pollution Conference, there was considerable discussion as to the cutoff for applicability of numerous design and construction measures under consideration. None of the tonnage cutoffs previously used in SOLAS agreements appeared to be appropriate. It was decided to examine the world tanker fleet as a result of this discussion, 20,000 DWT was chosen by the United States as a figure which would achieve this objective. The United States pushed for the 20,000 DWT lower limit because it would include nearly all of the foreign flag tankships that would call at U.S. ports. However, the characteristics of the world tankship fleet were changing during the early 1970's. The market for VLCCs was booming and represented a significant upward shift in the size of tankers. Fewer vessels were carrying a greater percentage of worldwide cargo. As a result, the overwhelming opinion at the Conference was that discharge standards should apply to all vessels, but new design and construction measures, particularly SBT, should be applied only to new tank vessels of 70,000 DWT and above.

As part of this study the figure of 20,000 DWT was examined in relation to the existing fleet of tankships eligible for U.S. domestic trade. As indicated in Figure 1, there are a group of 16 tankships between 16,000 and 20,000 DWT that are very similar in form and function to the 75 tankships in the 20,000 - 30,000 DWT size group. There are no ocean-going tankships in the domestic trade between 5,000 DWT and 16,000 DWT. Rather than establish a rather arbitrary dividing line at 20,000 DWT which would divide the group of WWII T2 and jumboized-T2 tankers, the study group felt that establishing a lower limit of 5,000 DWT more properly took into account the size distribution of the existing fleet. This also avoids the possibility of vessels slightly larger than 20,000 DWT accepting a reduction in cargo carrying capacity in order to escape regulatory requirements.

### 3.1.2 Regulatory Alternatives - SBT, CBT, IGS, Second Radar, and Emergency Steering

Early in the study, analysis of demand for tankship transportation services led to the conclusion that because of declining demand, it is not anticipated that there will be a significant building program for vessels in the 5,000 - 40,000 DWT size range in the near future. Analysis of impacts is therefore concerned mainly with existing ships. With this in mind, the tankship construction and equipment alternatives shown in Table 7 were identified for evaluation. Nomenclature used for regulatory measures in defined in Appendix A.

Information on the assessment of the impact of these alternatives on the marine environment are presented in Appendix C and Section 4.2. Information on cost imapcts is contained in Appendix E and Section 4.3. Information on safety impacts is contained in Section 4.4.

### 3.1.3 Other Equipment Requirements

In addition to the detailed consideration given to extension of TSPP requirements or application of Presidential Initiative requirements to smaller tankships, the study group identified other equipment requirements which should have an impact on oil outflows. 1

The following regulatory measures already in process by the Coast Guard should improve the degree of compliance with operational oil discharge standards already in effect:

Oil/water separator, 46 CFR 162 (docket No. CGD 76-088a), which would establish approved procedures and specifications for oil-water separators, cargo and bilge oil-content monitors, and bilge oil-content alarms for use on merchant vessels, final Regulation, August 1978.

Tank Vessel Regulations, 33 CFR 157, (docket No. CGD 76-088b), which would specify requirements for installation and use of oil-water separators, final regulation, October 1978.

The following regulatory measures should reduce the likelihood of vessel navigation errors leading to collision and grounding accidents:

Specification for Radar 33 CFR 164 (docket No. CGD 77-085), which would develop specifications for radar systems on vessels over 1,600 gross tons, Notice of Proposed Rulemaking (NPRM), December 1978.

Navigation Equipment, 33 CFR 164, (docket No. CGD 77-168), which would require Loran-C or alternative electronic navigation system on all vessels of 1,600 gross tons and over, NPRM June 1978.

Position Transmitting Device, 33 CFR 82 (docket No. CGD 77-243), which would amend Prince William Sound Vessel Traffic regulations to require Loran Position Transmitting Devices, NPRM 1978.

## 3.2 ACTIONS RELATING TO IMPROVEMENTS OF CREW STANDARDS AND TRAINING

A number of actions relating to improvements of crew standards and training which are in progress or under consideration should have an impact on accidents and oil outflows.

Coast Guard regulatory actions in this area include:

Qualifications of the person in charge of Oil Transfer Operations, Tankerman Requirements (docket No. CGD 74-44a, 74-44), which would refine and establish qualifying criteria for certifying individuals responsible for carriage and transfer of dangerous cargoes in bulk (including oil). Final Rule, September 1978.

1 Information on regulatory measures in this section updated from notice published by the Department of Transportation, Office of the Secretary, "Regulations Agenda," 43 Federal Register 23884-23922, June 1, 1978.

Observer Endorsement for Personnel (docket No. CGD 76-193a), which would require specialized training in use of radar equipment, NPRM August 1978.

Licensing of Pilots (docket No. CGD 77-084), a proposal which would require recency of service for each route upon which a pilot is authorized to serve; licenses to be issued with tonnage limitations commenserate with pilot experience; and consideration of shiphandling simulator training for pilots of large vessels. NPRM to be published December 1978.

Pilots on Self-Propelled Vessels, 33 CFR 163 (docket No. CGD 75-236), which would require pilots in certain areas not now covered by State Laws, NPRM July 1978.

In addition to the regulatory actions outlined above, the Coast Guard intends carefully to appraise the results of the International Conference on Training and Certification of Seafarers now in progress in London. Where results of that conference offer potential for improvement to present U.S. Standards and Practices, these results will be incorporated into U.S. requirements as appropriate.

In addition to the regulatory actions outlined above, a number of other actions to improve training and performance of U.S. tankship crewmen are underway. The Maritime Administration has prepared a curriculum for pollution prevention training which is now being used by various training establishments in training seamen. Questions on pollution prevention requirements have been incorporated into Coast Guard licensing examinations. These and other similar actions should have an impact on operational oil outflows and spills associated with transfer of cargo and fuel oil on tankships and tank barges as well as other vessels. Improvements to firefighting and radar training facilities and use of shiphandling simulators for training (measures being carried out on a cooperative basis between the Maritime Administration and the Coast Guard) should have an impact on the occurrence and results of vessel accidents. While it may not be possible analytically to demonstrate quantitative results of these and similar efforts in terms of reduced oil outflow or lower accident rates, there is almost universal agreement among experts that these efforts are potentially the most productive tanker safety and pollution prevention measures.

## 3.3 ACTIONS RELATING TO RECEPTION FACILITIES FOR OILY WASTES

Reception facilities for oily wastes were recognized by the 1973 Marine Pollution Conference as a key element in an overall strategy to reduce oil discharges to the marine environment. Although measures such as segregated ballast tanks or clean ballast tanks, load-on-top (or retention-on-board) procedures, improved cargo tank and piping stripping systems, and shipboard oil/water separating equipment may reduce the overall required capacity of reception facilities, facilities to receive oily mixtures and residues which cannot be treated and legally discharged at sea must be provided.

Regulation 12 of Annex I and Regulation 7 of Annex II of MARPOL 73 require each government to undertake means to insure the provision of adequate reception facilities in ports. In order properly to implement these regulations, each Administration is faced with a two-fold problem: (a) to develop means to insure that adequate reception facilities are provided, and (b) to develop guidelines to determine the adequacy of reception facilities in order to meet the needs of ships without causing undue delay to these ships. Development and publication by IMCO of guidelines on reception facilities for oily wastes (reference 5) provides a partial solution to half of this problem - guidelines still must be developed for chemical wastes.

Consideration of reception facilities by the study group was limited to a brief survey of literature available and the identification of key questions regarding their role in avoiding operational discharges from U.S. tankships in domestic trade.

Several papers on reception facilities were presented at the IMCO Symposium on Prevention of Pollution from Ships, held in Acapulco, Mexico, in March 1976 (References 6-9). Several of these describe procedures for determining reception facility needs and the design and construction of new reception facilities. Since MARPOL 73 introduced regulations governing special areas which were to enter into force in January 1977 classifying the Mediterranean Sea as a special area, efforts to provide adequate reception facilities by Medeterranean countries may well be ahead of those by other nations. Experience with new reception facilities in these countries as well as with the reception facility at Valdez should provide information on cost, performance, and possible improvements for use in planning any new reception facilities needed to meet MARPOL 73 requirements.

A key uncertainty identified in Appendix C in assessing oil inputs from tankship cleaning and ballasting operations is to what degree are reception facilities available and utilized? Although Coast Guard efforts are currently underway to determine availability and adequacy of reception facilities, no definitive answers are yet available. Reference (10) does present some preliminary results and conclusions of work to date, along with a number of questions requiring resolution. From these preliminary results, it appears that some sort

of loading port arrival inspection of the sort outlined in Section 3.6 coupled with a review of completed Oil Record Books and official logs are possible ways of determining the role reception facilities are currently playing.

## 3.4 "SPECIFIC TRADES" AND "SPECIAL BALLAST ARRANGEMENTS"

Two pollution prevention concepts developed at the TSPP Conference and included in the 1978 Protocol to MARPOL 73 were identified by the study group as having some potential for application to U.S. tankships in domestic trade. These are "specific trades" and "special ballast arrangements".

Regulation 13c of the 1978 Protocol to MARPOL 73 exempts existing oil tankships from requirements for SBT or CBT if these ships are engaged solely in specific trades between:

(a) ports or terminals within one country which is a party to the Protocol, or

(b) ports or terminals of States Parties to the Protocol where the voyage is entirely within a special area (such as the Mediterranean) or within other limits adopted by IMCO at some future time.

This provision can only be applied when the ports or terminals where cargo is loaded are provided with reception facilities adequate for the reception and treatment of all ballast and tank washing water from oil tankers using them. In addition, all ballast water, including clean ballast water, and tank washing residues must be retained on board and transferred to the reception facilities. Regulation 13c also provides for detailed control measures to prevent abuse of the "special trades" exemption from SBT/CBT requirements and requires that where two or more countries are involved, they must reach specific agreement concerning the use of an existing oil tanker for a specific trade.

The concept of the exemption of "specific trade" tankships from SBT/CBT requirements is tied directly to provision of reception facilities. It also applies only to existing vessels. Any "specific trade" exemption of existing U.S. tankships in domestic trade from any general requirement for SBT retrofit or CBT which might be imposed would have to be conditioned on the use of these vessels solely in specific trades where adequate reception facilities were available. Such a case might be where a product carrier is involved in regular runs between a refinery where adequate reception and treatment facilities are available and one or more product distribution terminals. Another possible application might be to a crude oil carrier dedicated to moving OCS crude oil from an offshore production facility where adequate reception and treatment facilities for ballast and tank washing residues are available to a refinery or terminal on shore.

Regulation 13d of the 1978 Protocol to MARPOL 73 provides that where an existing oil tanker is constructed and operates in such a manner that it complies with the minimum draft and trim requirements in Regulation 13 (2) of MARPOL 73 at all times without recourse to the use of ballast water, is shall be deemed to comply with the requirements for SBT.

A number of "special ballast arrangements" are conceptually possible. A tankship may be equipped with adequate "fixed ballast" (concrete, lead weights, iron pigs, or "locked-in" water ballast which always remains aboard) so that additional water ballast is not required. Or, a vessel may be used on a route such that it is always partially loaded (with cargo or fuel oil) and therefore never needs to take additional water ballast to meet minimum draft and trim requirements.

In order to avoid possible abuse of the "special ballast arrangements" exemption from SBT/CBT requirements for existing tankships, operational procedures and ballast arrangements must be approved by Flag State Administrations, agreement must be reached with any other Port State Governments involved, and the vessel's International Oil Pollution Prevention Certificate must be endorsed to indicate use of "special ballast arrangement" concept.

While the "special ballast arrangements" concept might be of some benefit in avoiding operational discharges from ballasting of dirty cargo tanks, it (like SBT and CBT) does not have a significant impact on oil inputs from tank washing.

Special ballast arrangements may be important alternatives to SBT/CBT for smaller product tankships on short routes and possibly to tankships used to bring crude oil ashore from OCS production facilities. The key concept is that the tankship can always maintain adequate draft and trim without taking additional water ballast.

## 3.5 ACTIONS RELATING TO THE WATER WAY AND OPERATING RULES

The Coast Guard has authority under existing laws for a number of types of actions affecting the waterways and vessel operating controls and restrictions.

These actions can reduce the likelihood of tank vessel collisions, rammings, groundings fires, and explosions and resulting oil discharges.

Improvements to vessel traffic services and controls and improvements to aids to navigation systems are both potential areas for avoiding future tank vessel collision and grounding accidents. Use of traffic separation schemes, regulated navigation areas, vessel routing systems, and vessel surveillance and control systems are all topics being investigated as part of a study of offshore vessel traffic management requested by the President and being conducted for the Coast Guard by the Department of Transportation's Transportation Systems Center in Cambridge, Massachusetts. This study is due to be completed and delivered to the President by 1 October 1978. Measures of the sort being studied may be particularly appropriate in certain areas if future transportation of OCS crude oil should result in a large increase in tankship and tank barge traffic. Improved aids to navigation, both short-range aids (buoys, daymarks, ranges, etc.,) and electronic aids (radiobeacons, Loran -C, radar transponders, satellite navigation systems, etc.) should also be considered where shifts in transportation patterns, such as those which may accompany OCS oil development, may subject a coastal area to greater risk of tank vessel accidents.

3.6 ACTIONS RELATING TO ENFORCEMENT EFFORTS

Coast Guard enforcement efforts relative to U.S. tankships in domestic trade are aimed at:

. obtaining compliance with the oil discharge standards described on page 30, by ensuring that tankships are properly equipped and maintained to carry out LOT/ROB procedures, and detecting and punishing voilations of the discharge standards, and

. avoiding accidents, through inspection and boarding programs to make sure vessels are in compliance with current safety regulations.

The Coast Guard believes on the whole its enforcement programs for U.S. tank vessels are effective, although some improvements in administration in the following areas may offer some potential for improved effectiveness:

MSIS, the Marine Safety Information System, now in use by Coast Guard field offices to obtain information on past violations by specific vessels of safety and pollution prevention regulations, previous pollution incidents by a vessel, previous Coast Guard boarding and inspection, and accidents involving foreign tank vessels.

A contract for prototype development of an expanded MSIS was awarded in January 1978.

The ultimate aim of this long-term project is a comprehensive marine safety information system accessible to all users within the Coast Guard whose activities encompass marine safety (i.e., boarding officers, accident investigators, field inspectors, and engineers and analysts preparing regulation changes.)

Loading port inspections of tankships offer potential for improving the degree of compliance with oil discharge standards now in effect as well as in obtaining information to assess present degree of compliance, amount of oily wastes being generated, and use of reception facilities. The procedures developed for monitoring of crude oil tanker load-on-top procedures, detailed in reference (11), should be adapted for use in loading port inspection of product tankers. Loading port inspection of product tankships should ascertain the type and amount of cargo last carried, the amount of tank washing and ballasting done on the return trip, and what was done with the oily residues - were they retained on board and discharged to reception facility or disposed of at sea (either legally or illegally). This information, obtained from interviewing the vessel's master and an inspection of the Oil Record Book, official logs and other records on the vessel will give an indication of how oily residues are being handled and degree of compliance with discharge standards. Coast Guard inquiry into these areas should also

encourage better compliance if vessels are not now in compliance.

In addition to inspection of a vessel's Oil Record Book in conjunction with routine boarding or loading port inspection as outlined above, a review of completed Oil Record Books (required to be submitted to the Coast Guard by 33 CFR 151.35(h)) should also produce information on compliance with regulations. Are the Oil Record Books being properly kept as required by 33 CFR 151.35? Is the information recorded adequate to draw some inference concerning amounts of ballast and tank washing done, extent of use of reception facilities, discharges made at sea, etc? What inferences can be drawn on these questions? A review of a sample of the completed Oil Record Books now on file should be relatively easy to accomplish and may provide information of use in further enforcement efforts.

Surveillance for illegal oil discharges and followup investigations and prosecutions are another important aspect of Coast Guard enforcement efforts. Advances in oil spill "fingerprinting" and aerial surveillance techniques have and will continue to improve the effectiveness of enforcement efforts.

## 3.7 ACTIONS RELATING TO ECONOMIC RESPONSIBILITY

One element of the Presidential Initiatives was approval of comprehensive oil pollution liability and compensation legislation. With this in mind, some discussions were held early in the study of the value of measures which (1) revised the limitations to civil liability for oil pollution injuries, or (2) made more severe the sanctions which may be imposed for discharging oil. The assertion here is that these actions would make it more costly for a vessel owner or operator to discharge oil and consequently the owner or operator would exercise greater care in avoiding the discharge.

Noting that various liability schemes were discussed in great detail in the Interim Report of the Marine Oil Transportation Task Force (reference 12) and that legislation in this area was still under consideration by the Congress, measures in this area were not considered further by the study group.

In a related action, the Coast Guard has issued a notice of proposed reulemaking related to notification of tank vessel ownership:

> "Notification of Tank Vessel Ownership Information and Name," docket No. CGD 77-213, which would require that tank vessel owners and operators advise the Coast Guard of identity and ownership of tank vessels entering navigable waters of the United States, NPRM July 1978.

# 4. EVALUATION OF ALTERNATIVE PREVENTIVE ACTIONS

## 4.1 INITIAL SCREENING

Recognizing that time was not adequate thoroughly to evaluate all of the alternative preventive actions identified, the study group concentrated on evaluating the vessel construction and equipment measures identified with consideration being give to other types of measures where they appeared to be particularly promising alternatives or valuable supplements. Quantitative estimates of the environmental, economic, and safety impacts of SBT, CBT, IGS, Second Radar, and Emergency Steering Improvement measures applied as part of

- extension of the requirements of the 1978 Protocols to SOLAS 74 and MARPOL 73 (commonly referred to as "TSPP requirements") down to smaller tankships, and

- application of requirements originally contained in the Presidential Initiatives to smaller tankships.

Other beneficial measures qualitatively evaluated include:

requirements for oil-water separators and oil content monitors and alarms.

navigation equipment requirements for tank vessels.

actions to improve training and performance of tank vessel crews.

reception facilities, "specific trades," and "special ballast arrangements".

improvements to vessel traffic services and controls

improvements to aids to navigation systems

further development of MSIS, the Marine Safety Information System

introduction of loading port inspections of tankships

review of completed Oil Record Books

improved oil spill surveillance and investigation techniques

## 4.2 ENVIRONMENTAL IMPACTS

Coast Guard estimates indicate that, depending on a number of

factors, the following measures could have a significant impact on oil inputs from U.S. tankships in domestic trade:

- SBT on existing tankships could reduce operational oil inputs by eliminating ballasting of cargo tanks and tank cleaning to provide space for clean ballast as sources of operational oil inputs, and

- Protective location of SBT or double bottoms devoted to segregated ballast on new tankships could, in addition to operational benefits of SBT, reduce accidental oil inputs from tankships by providing increased protection against oil outflow following grounding or collision.

The impact of SBT on operational oil inputs from product tankers would be limited to inputs from ballasting of dirty cargo tanks and tank cleaning to provide space for clean ballast. SBT would not affect tank cleaning done for other reasons, which on product carriers is the bulk of the tank cleaning done. Details of estimates of the impact of SBT and CBT on oil inputs are shown in Appendix C and Figure 4 (reproduced from Appendix C). Under the assumptions used for making these estimates, the impact of SBT or CBT on 1985 estimated oil inputs from U.S. tankships, 5,000 dwt - 40,000 dwt, in domestic product trade may be summarized as follows:

> SBT or CBT might achieve a reduction in operational oil discharges ranging from some very small amount to about 18,000 metric tons (135,000 barrels) per year, depending on the amount of ballasting product tankers do and the degree of compliance with the operational discharge standards already in effect (the greater the degree of present compliance with these existing standards, the smaller the reduction achieved by the retrofit of SBT or CBT). This potential reduction is due entirely to reduction in oily departure ballast discharges from product carriers. Other discharges would not be affected by SBT or CBT. The estimated discharge amounts are strongly a function of the degree of compliance with operational discharge restriction already in effect.[1] Measures which improve the degree of compliance with these restrictions in reducing and treating oily mixtures created as a result of tank washing to avoid contamination of next cargo, such as improved stripping and flushing of cargo piping, oil content monitors and oily-water separators, improved slop tank design, loading port inspection, and improved surveillance, can have a marked effect on operational oil inputs from U.S. tankships in the domestic product trade.

Measures which offer potential for preventing collision, ramming, and grounding accidents (Second Radar, CAA, Emergency Steering Improvements, improved navigation equipment and aids to navigation systems, actions to improve training and performance of tank vessel crews, and improvements to vessel traffic services and controls) or preventing oil outflow following such accidents (PL/SBT or DB on new tankships) might also avoid as much as an average annual accidental

[1] Operational discharge standards in effect are described on page 30.

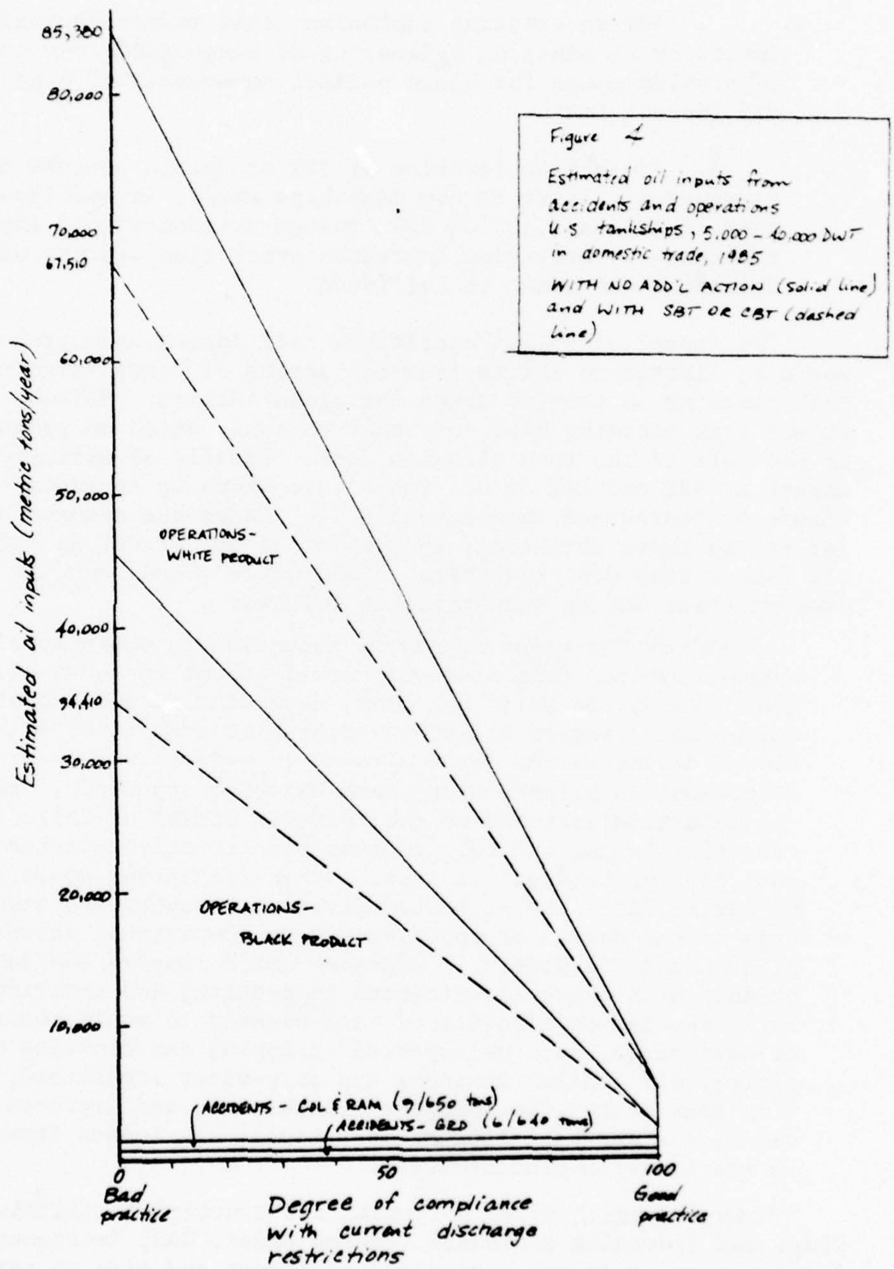

Figure 4
Estimated oil inputs from accidents and operations U.S. tankships, 5,000 - 40,000 DWT in domestic trade, 1985
WITH NO ADD'L ACTION (Solid line) and WITH SBT OR CBT (dashed line)
Estimated oil inputs (metric tons/year)
85,380
80,000
70,000
67,510
60,000
50,000
40,000
34,410
30,000
20,000
10,000
OPERATIONS - WHITE PRODUCT
OPERATIONS - BLACK PRODUCT
ACCIDENTS - COL & RAM (9/650 tons)
ACCIDENTS - GRD (6/640 tons)
0
50
100
Bad practice
Good practice
Degree of compliance with current discharge restrictions

oil input of 1300 metric tons. The actual reduction achieved would depend on the degree of effectiveness of the measures adopted.

The maximum potential inpact of extending TSPP requirements or of applying Presidential Initiative measures to smaller U.S. tankships in domestic trade is a reduction in accidental and operational oil inputs of an estimated 19,300 metric tons per year (maximum possible of 18,000 from operational, 1300 from accidental). The actual inpact could be considerably smaller than this maximum potential value, depending on amount of ballasting product tankers do, degree of compliance with operational discharge standards in effect, and effectiveness of accidental discharge measures adopted. It is not possible to say what inpact such an oil outflow reduction might have on damage to the marine environment, except in general terms as outlined in Section 2.3.2.

## 4.3 ECONOMIC IMPACTS

This section reviews the short term cost impact of five regulatory tanker safety and pollution prevention alternatives. The analysis is based upon the projected supply and demand for the U. S. tanker fleet with and without the implementation of the alternative packages. Estimated required freight rates (RFR's) are used as the basis for deciding economic viability of the vessels in the fleet in satisfying the projected transportation demand.

Because of the large expected decline in demand no new construction was expected under any of the regulatory alternatives. This analysis, however, is sensitive to level of demand and does not take into account non-quantifiable items such as owners' preference.

The five alternative equipment requirement packages analyzed are described in Table 7. Packages 1 and 2 extend the TSPP Conference requirements down to 5,000 DWT tankers but also require the SBT retrofit in alternative 1 while only CBT retrofit in alternative 2. Alternative 3 reflects the Presidential Initiatives as proposed down to the 20,000 DWT limit. Alternatives 4 and 5 are identical to alternatives 1 and 2 except IGS retrofit is not required.

A summary of the resultant annual cost impacts for the short term cost impact analysis of the five alternatives is shown on Table 8.

These numbers are based upon a supply and demand analysis explained in detail in Section 2.1.2.2. The analysis assumes a 1985 demand for oil transportation and adjusts the fleet on the basis of economic costs to meet the demand. 1985 was chosen because it was assumed that any regulatory action would be implemented by that time. The retrofit period is a time when demand for domestic trade is expected to decline from 3.9m DWT to 2.2m DWT because of increased application of pipelines.

Total existing fleet capital costs are the totals for retrofit expenditures. The average capital cost is then developed on a per retrofitted tanker basis.

The percent reduction in effective fleet cargo capacity from retrofit is a measure of the amount of DWT carrying capacity that is lost by the retrofitted vessels in the fleet. Additional annual costs represent variations in operating costs and the amortized capital costs on a fleet basis. These additional costs are then expressed as a percentage of the base 1985 fleet costs and as the cost increase per gallon of oil transported by this fleet.

The increase in annual costs for each of the regulatory alternatives is largely attributable to the reduction in cargo carrying capacity due to SBT or CBT, the increased number of ships needed to transport the same amount of cargo and high capital outlays to comply with requirements for IGS.

TABLE 7

REGULATION PACKAGE ALTERNATIVES FOR PRODUCT TANKERS

REQUIRED EQUIPMENT

| Regulation Alternative | SBT | CBT | DB | Second Radar | CAA | ICS | Emergency Steering Gear | DWT Lower Limit |
|---|---|---|---|---|---|---|---|---|
| 1 Existing | Reqd. | | | Reqd. | Reqd. | Reqd. | Reqd. | 5,000 |
| New | Reqd. | | | Reqd. | Reqd. | Reqd. | Reqd. | 5,000 |
| 2 Existing | | Reqd. | | Reqd. | Reqd. | Reqd. | Reqd. | 5,000 |
| New | Reqd. | | | Reqd. | Reqd. | Reqd. | Reqd. | 5,000 |
| 3 Existing | Reqd. | | | Reqd. | Reqd. | Reqd. | Reqd. | 20,000 |
| New | Reqd. | | Reqd. | Reqd. | Reqd. | Reqd. | Reqd. | 20,000 |
| 4 Existing | Reqd. | | | Reqd. | Reqd. | | Reqd. | 5,000 |
| New | Reqd. | | | Reqd. | Reqd. | | Reqd. | 5,000 |
| 5 Existing | | Reqd. | | Reqd. | Reqd. | | Reqd. | 5,000 |
| New | Reqd. | | | Reqd. | Reqd. | | Reqd. | 5,000 |

The alternatives 4 and 5 show that the effect of not including IGS as a requirement in alternatives 1 and 2 is to reduce annual costs by about 7 percent.

The Presidential Initiatives alternative increases annual costs only 35 percent, since only about 2/3 of the ships under consideration have to be retrofitted. Extension of the requirement down to 5,000 DWT would increase this percentage to slightly more than the 44 percent increase of alternative 1 (because of the Presidential Initiative requirement for double bottoms on new ships).

To analyze further the possible regulatory options the components of the capital and annual cost of the alternatives is presented in Table 9. The effect on costs of the second radar, the CAA and emergency steering gear are seen to be quite small. This is because the TSPP requirement for these items extends to 10,000 GRT which is roughly equivalent to 20,000 DWT.

A different type of impact is that which the required capital expenditures will have on the national economy in the years when they occur. These expenditures increase the demand for resources and may increase price levels or real national production. Table 8 also shows average levels of capital outlay for 1981-1985.

TABLE 8 SUMMARY OF CAPITAL AND ANNUAL COST IMPACTS

| | Regulation Alternative | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Total Existing Fleet Capital Cost (Million) | \$215.19 | \$143.43 | \$210.59 | \$71.22 | 0 |
| Average Capital Cost Per Tanker (Million) | \$ 2.42 | \$ 1.61 | \$ 2.06 | \$ 0.77 | 0 |
| Reduction in Effective Fleet Cargo Capacity from Retrofit (Percent) | 21 | 21 | 21 | 21 | 22 |
| Number of New Vessels Constructed | 0 | 0 | 0 | 0 | 0 |
| Capital Cost of New Construction | 0 | 0 | 0 | 0 | 0 |
| Additional Annual Costs (\$ x $10^6$) | 153.2 | 140.8 | 116.5 | 127.6 | 110.3 |
| % Increase in Annual Costs | 44 | 41 | 34 | 37 | 32 |
| Additional Cost/Gallon of Oil Transported (¢) | 0.74¢ | 0.68¢ | 0.56¢ | 0.61¢ | 0.53¢ |

TABLE 9 COMPONENT EFFECT ON CAPITAL AND ANNUAL COST IMPACTS

| | Regulation Alternative | | | | |
|---|---|---|---|---|---|
| Existing Fleet Capital Costs ($ x $10^6$) Millions | 1 | 2 | 3 | 4 | 5 |
| SBT | 72 | 0 | 66 | 71 | 0 |
| CBT | 0 | 0 | 0 | 0 | 0 |
| Second Radar<br>CAA | 0 | 0 | 1.8 | 0 | 0 |
| IGS | 143 | 143 | 143 | 0 | 0 |
| Emergency Steering Gear | 0 | 0 | 0 | 0 | 0 |
| Total | 215 | 143 | 211 | 71 | 0 |

### 4.4 SAFETY IMPACTS

The Presidential Initiatives of 17 March 1977 called for the fitting of inert gas systems (IGS) on all tankers over 20,000 dead weight tons. The International Conference on Tanker Safety and Pollution Prevention, London, 1978 substantially met these requirements.

All new tankers of 20,000 dwt (Crude and product) must be fitted with IGS. All existing Crude Carriers of 20,000 dwt and above must be fitted with IGS except that in cases where it is physically impossible to retrofit between 20-40,000 tons dwt the Administration may permit an exception on a ship by ship basis. All existing product carriers of 40,000 tons dwt and over must be fitted with an IGS. Any tank vessel above 20,000 dwt which is fitted with fixed high capacity washing machines must also be equipped with an IGS. These new provisions represent a substantial increase in the number of vessels required to be fitted with IGS. The primary disparity between the Presidential Initiatives and the results of TSPP is for existing product tankers that are below 40,000 tons deadweight. This differential was a recognition by the conference of several factors:

(a) Fewer fires and explosions have occured in product carriers than in Crude Carriers.

(b) Product carriers have a greater degree of complexity with respect to piping and vapor management and are generally better maintained due to requirements for product purity.

(c) Retrofit of IGS to existing product carriers could increase the complexity of the overall cargo management system to the point where a hazard was created rather than diminished.

(d) the cost and complexity of refrofit did not justify installation.

A reexamination of fire and explosion data for the period 1963-1975 does not indicate the need for fitting of IGS below the limits developed at the February conference for U.S. flag product carriers. The above noted factors form a basis for this conclusion.

With respect to U.S. flag vessels, there are several factors which should be examined which are peculiar to the way U.S. tank ships differentiate between Crude and product service. Currently tank vessels are certificated to transport specific grades of cargo. These grades are based on the flashpoint and vapor pressure of the liquids. Grade A represents a cargo of potentially greater hazard than a Grade E cargo (diesel fuel). Grades B, C, & D are intermediate cargoes. It is common to certificate a tanker to carry Grades A-E, thus permitting the vessel to engage in carriage of all types of Crude oil and products. In the future, since U.S. regulation will require fitting of IGS on existing Crude

Carriers of 20,000 tons dwt and product carriers of 40,000 tons dead weight, an owner will have to decide whether or not his vessel should maintain the flexibility of carrying both product and Crude.

There are convincing arguments that the benefits accured from fitting IGS on existing ships below the levels developed by the conference are outweighed by the costs of installation.

There is no question about the ability of a properly operating and designed inert gas system to prevent the potential for a cargo tank explosion and this recommendation in no way should be viewed as a retrograde step from what has been currently accomplished.

On a historical note it is worth pointing out several facts with respect to fitting of IGS.

a. IGS is primarily aimed at safety rather than pollution prevention. Less than ½ of 1% of the oil that enters the world's oceans is due to fires and explosions.

b. Between 1963 and 1975 there were 27 fires or explosions involving liquid cargo on U.S. flag tank ships. Eleven of those incidents resulted in 65 deaths. Installation of IGS could have prevented only some of these casualties. Other less costly measures have been used to prevent explosions such as the removal of magnesium anodes from cargo tanks.

The frequency of fires and/or explosions involving a vessels' cargo has been relatively low, nineteen out of a possible twenty-nine. Severity as might be expected is high, especially when measured by number of deaths per incident. As indicated, however, a single incident skews this result substantially. The V.A. FOGG, where all hands were lost, was in the process of tank cleaning and gas freeing when the vessel exploded and sank. The configuration of the vessel was such that it was necessary to hand mop remaining puddles of cargo prior to gas freeing.

This hand mopping required tank entry which required an atmosphere sufficient in oxygen to support life, but that concentration also could permit sections to be in the flammable range. Whether or not an IGS system could have prevented this casualty is debatable on the facts.

Based on analysis of casualties and economical consideration versus benefits, it would not appear justifiable to require IGS beyond the limits agreed to at the Conference.

## 4.5 ENERGY IMPACTS

From the conversation of energy viewpoint, the requirement for operation with CBT or for SBT retrofit increases energy consumption. Quantities of bunker fuel required for transportation will increase consequent to implementation of these requirements. Bunker consumption for a 30,000 DWT U. S. tanker with and without SBT retrofit or CBT operation can be calculated as follows:

$$\text{Base Tanker Consumption} = \frac{495 \text{ BBl}}{\text{Sea Day}} (7.09 \text{ Days}) + \frac{84 \text{ BBl}}{\text{Port Day}} (3 \text{ Days}) \frac{34.71 \text{ Trips}}{\text{Year}}$$

$$= 130{,}391 \text{ BBl/Year} = \frac{130{,}391 \text{ BBl/Yr}}{986{,}184 \text{ LT/YR}} = \frac{.132 \text{ BBl}}{\text{LT Cargo Transported}}$$

$$\text{SBT/CBT Consumption} = 495\ (6.91) + 84\ (3)\ \ 35.32$$

$$= 129{,}710.93 \text{ BBl/YR} = \frac{129{,}710.93}{769{,}003} = \frac{.169 \text{ BBl}}{\text{LT Cargo}} \text{ Transported}$$

The 30,000 DWT SBT retrofitted tanker on its 2,720 mile voyage thus uses .037 BBl of bunkers more per ton of cargo delivered than the base design. Additional bunkers used by the retrofitted vessels are roughly approximated by applying the following type difference to the total projected retrofitted tonnage:

$$\frac{\text{BBl/Yr}}{\text{Tanker DWT}} \approx \frac{986{,}184 \text{ LT/YR}}{30{,}000 \text{ DWT}} \times \frac{.037 \text{ BBl}}{\text{LT/YR}} = 1.19 \text{ BBl/DWT}$$

Results are shown below for the U. S. tanker fleet 5,000 DWT-40,000 DWT:

4,351,800 DWT x 1.19 BBl/DWT = 5,178,642 Additional barrels of bunkers used per year.

In addition, shipyards will expend some energy in performing the retrofit of SBT on the existing fleet.

## 5. CONCLUSIONS

Early in the study, an examination of the risks associated with the marine transportation of oil by U. S. tank vessels in domestic trade indicated that the fleet of U. S. tankships in the size range 5,000 DWT to 40,000 DWT was of primary concern and should be the focus of study efforts. Projections are that U. S. tankships of this size will, in 1985, be engaged almost exclusively in the carriage of petroleum products, although it is possible there may be some future use of vessels of this size to transport OCS crude oil to shore. Demand for U. S. tankships in domestic trade is expected to decline by about 40% from 3.9 to 2.2 million deadweight tons between now and 1985 due to development of pipeline alternatives to transportation of oil by tank vessel. The development of one or more crude oil pipelines from the West Coast to mid-continental refineries is expected to eliminate the need for small tankships currently used in the trans-Panama route for Alaskan oil. Product pipelines between the Gulf Coast and the mid-Atlantic states are also expected to expand their capacities in response to cost advantages over tankships. Because of declining demand for U. S. tankships of 5,000 DWT to 40,000 DWT in domestic trade, it is not anticipated that there will be a significant building program for this size for this trade in the near future.

The hazards identified as being of greatest concern are:

- o oil discharges, including operational oil discharges from ballasting and cleaning of cargo oil tanks, which represent a large portion of the total oil discharges, but have a lower per-incident environmental impact; and accidental oil discharges from collision, ramming, and grounding accidents, which represent a small portion of the total oil discharges, but have a high per-incident environmental impact; and
- o fires and explosions on tankships, which result in very little oil being released, but can represent a serious hazard to people and property, both on and off the vessel.

A number of possible preventive actions were identified and examined during the study including:

- o extension of the construction and equipment requirements of 1978 Protocols to SOLAS 74 and MARPOL 73 (referred to as "TSPP requirements") down to smaller tankships[1]

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[1]The Coast Guard was requested to evaluate this proposal by the Deputy Secretary of Transportation in his memorandum of 29 March 1978, reference (2).

- application of construction and equipment requirements originally contained in the Presidential Initiatives to smaller tankships[2]

Individual measures which are components of these two construction and equipment "packages" were also examined (e.g., segregated ballast tanks, clean ballast tanks, inert gas systems, protective location of segregated ballast, second radar, collision avoidance aids, and emergency steering improvements). A broad spectrum of other preventive actions, some in process of being implemented and others under consideration by the Coast Guard, were identified but were not examined in detail due to the time constraints on the study.

As part of this study, attempts were made to estimate the impact of possible preventive actions on accidental and operational oil discharges and damage to the marine environment resulting from oil discharges, incidence of tankship fires and explosions, and transportation costs and capital requirements, all as of 1985 when measures would be fully in effect. Results of these estimates are summarized in the following paragraphs.

## IMPACT ON OIL INPUTS AND DAMAGE TO THE MARINE ENVIRONMENT

### Accidental Oil Inputs

Measures which would prevent collision, ramming, and grounding accidents to U.S. tankships in domestic trade might, if they were 100% effective, avoid an average of 9 collisions and rammings and 6 groundings with total estimated outflow of about 1300 metric tons (approximately 9750 barrels) per year. The actual impact of accident prevention measures could be expected to be something less than this maximum possible impact, depending on the effectiveness of measures actually implemented. While this amount is a relatively small portion of total oil inputs, accidental oil inputs tend to have a high impact per incident on the marine environment. A requirement for double bottoms or protective location of SBT on new tankships not covered by TSPP requirements (i.e., new crude oil tankships under 20,000 DWT and new product carriers under 30,000 DWT) would produce little accidental outflow reduction by 1985 if, as expected, few new ships of this size are built. Extension of TSPP requirements for second radar, collosion avoidance aids, and emergency steering improvements might provide some small accidental oil outflow reduction.

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[2]Evaluation of actions in this category was suggested by the Coast Guard in response to testimony before the Senate Committee on Commerce, Science, and Transportation on 5 April 1978.

## Operational Oil Inputs

Actions which require SBT or CBT on smaller tankships not covered by TSPP requirements might achieve reduction in 1985 operational oil discharges ranging from some very small amount to 18,000 metric tons (approximately 135,000 barrels) per year, depending on the degree of effectiveness of other discharge control measures in effect in 1985. (The more effective these other discharge control measures are, the smaller the potential impact of SBT or CBT.) Uncertainty over present and projected degree of compliance with operational discharge standards now in effect makes more precise estimates impossible to make at present.[3] However, the study has identified a number of actions which could reduce this uncertainty. These actions are discussed in the RECOMMENDATIONS section of the report.

## Overall Impact on Oil Inputs and Damage to the Marine Environment

The maximum potential impact of extending TSPP requirements or of applying Presidential Initiative measures to smaller U.S. tankships in domestic trade is a reduction in accidental and operational oil inputs of an estimated 19,300 metric tons (144,750 barrels)per year (maximum possible of 18,000 from operational, maximum possible of 1300 from accidental). The actual impact could be considerably smaller than this maximum potential value, depending on amount of ballasting product tankers do, degree of compliance with operational discharge standards in effect, and effectiveness of accidental discharge measures adopted. It is not possible to say what impact such an oil outflow reduction might have on damage to the marine environment except in general terms as outlined in Section 2.3.2 of the report. A basic question that remains unanswered is, "At what level of petroleum hydrocarbon input to the ocean might we find irreversible damage occurring?" Until we can come closer to answering this basic question, it seems necessary to continue efforts to control oil inputs and to push forward research to reduce our current level of uncertainty.

A further concern in considering impacts of a potential SBT or CBT requirement is that these measures would not materially affect 80% of the estimated oil inputs from operation of U.S. tankships in domestic trade (possibly as much as 66,000 metric tons (495,000 barrels) per year under "worst case" assumptions) which result from tank cleaning rather than ballasting. Improvements in this area must be sought through improvements to retention-on-board procedures and equipment on product tankers, proper use of reception facilities, and measures (such as loading port inspections) to increase the degree of compliance with discharge standards already in effect.[3]

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[3]Operational discharge standards now in effect are described on page 30 of the report.

Operational and Accidental Oil Inputs from Future OCS Crude Oil Movements by Tank Vessels

Tankships and tank barges which may be used in the future to transport crude oil produced on the Outer Continental Shelf (OCS) to refineries ashore represent a different problem from tank vessels involved in coastwise product movements. This is because the routes these vessels travel will probably be relatively short and largely in coastal waters, and because of the likely difficulties in providing ballast reception facilities at offshore loading terminals. It is not possible quantitatively to estimate potential oil inputs from these vessels, since we do not know how much oil will be found in new OCS areas where transportation of oil by tankship or tank barge may be more feasible than pipelines. But treatment and disposal of oily mixtures from ballasting and tank washing from OCS tankships in compliance with existing discharge standards[3] solely by using load on top procedures does not appear feasible. Depending on the amount of oil found and the mode of transportation used to bring this oil ashore to refineries, it is possible that future transportation of OCS Crude oil could result in an increase in tankship and tank barge traffic in some areas, leading to increased risk of accident. Again, it is not possible quantitatively to estimate possible future oil inputs from these sources due to uncertainties in the amount of oil to be moved by tank vessels.

## IMPACT ON TANKSHIP FIRES AND EXPLOSIONS

Actions which extend inert gas system requirements to tankships smaller than those included in the SOLAS Protocol (primarily existing product carriers below 40,000 DWT) could be expected to have only a small impact on incidence of tankship fires and explosions on these vessels. The incidence of fire and explosions on these smaller vessels is relatively low and an IGS requirement would not be effective in preventing most of the fires and explosions which do occur.

## IMPACT ON TRANSPORTATION COSTS AND CAPITAL REQUIREMENTS

Cost estimates in the study indicate that extending TSPP requirements or applying Presidential Initiative measures to smaller U.S. tankships in domestic trade would, in 1985, cost on the order of \$100-\$150 million per year in increased transportation costs. This represents an estimated increase of about 32-44% in transportation costs. The main reason for this increase is that tankers of the size being considered here would lose about 20-30% of their cargo carrying capacity if CBT or SBT were required. If increased transportation costs are passed on the consumer in the form of higher oil costs, this would correspond to an increase of about one-half to three-quarters of one cent per gallon transported. Capital costs for the domestic fleet range from near zero to \$215 million for the various alternatives examined. These capital costs are summarized in Table 8.

Following are specific conclusions:

Inert Gas Systems

Extension of the requirement for IGS to ships smaller than those included in the SOLAS Protocol does not appear to be justified in view of the small number of fires and explosions which might be prevented, rather severe installation problems encountered on small existing tankships, and the relatively high costs of installing IGS systems on these vessels.

OCS Crude Oil Movements

Measures to control oil discharges which may result from future transportation of OCS Crude oil by U.S. tankships in domestic trade are highly desirable. SBT, CBT, Specific Trade, or Special Ballast measures appear to be effective alternatives for controlling future operational oil discharges from U.S. tankships which may be used in this trade. Any requirements adopted now should incorporate adequate flexibility to permit use of any new equally effective techniques for dealing with the problem of oily residues from OCS tankships developed between now and when movement of OCS oil by tankships takes place. Transportation planning for OCS oil can also be monitored to anticipate any marked increase in tankship and tank barge traffic. Where such increases are anticipated in planning stages, the Coast Guard could reappraise vessel surveillance and control systems, vessel navigation system requirements and aids-to-navigation systems (both short-range and electronic) applicable to the anticipated movements and make appropriate changes to eliminate or control hazards due to increased vessel traffic.

General Extension of SBT or CBT Requirements

Considering the information available on cost and environmental impacts, TSPP requirements for SBT or CBT should not be extended to small U.S. tankships in domestic trade, except as outlined above for tankships which may be used to transport OCS crude oil. A decision not to extend requirements for SBT or CBT now does not foreclose doing so at some future time if new evidence indicates these measures would be effective in reducing damage to the marine environment. Before a decision to require these measures can be reached, better information must be obtained on the amount of oil being discharged from product carriers in domestic trade, the effect of these discharges on the marine environment, and the effectiveness of SBT or CBT in reducing the amount of oil being discharged. Specific ways to gather this information are outlined under RECOMMENDATIONS.

# 6. RECOMMENDATIONS

Following are recommendations for action to be taken:

1. Action should be initated to bring into effect additional measures to control oil discharges from future transportation of oil produced on the Outer Continental Shelf to shore by U.S. tankships of 5,000 DWT or more, both new and existing in domestic trade. SBT, CBT, Specific Trade, and Special Ballast measures appear to be effective alternatives for controlling future operational discharges from U.S. tankships which may be used in this trade. The issues of law involved in placing such requirements into effect (i.e., by legislation, regulation, conditions on permits, etc.) should be determined by the Chief Counsel of the Coast Guard and the General Counsel of the Department of Transportation. Any requirements placed in effect should allow sufficient flexibility to permit use of any new equally effective techniques for dealing with the problem which may be developed between the time regulations are issued and possible future OCS oil movements by tankship actually take place.

2. Transportation planning for OCS oil should be closely monitored in order to anticipate any marked increase in tankship or tank barge traffic in conjunction with movement of OCS oil to refineries. When potential increases in traffic are identified, the Coast Guard should reappraise vessel surveillance and control systems, vessel navigation system requirements, and aids-to-navigation systems (both short-range and electronic) in areas where traffic is expected to increase and make appropriate changes to eliminate or control hazards due to increased vessel traffic.

3. Beyond the action outlined above, TSPP requirements or Presidential Initiative measures should not be extended to smaller U.S. tankships in domestic trade. Action should be initiated to obtain better information on the present and projected quantities of oil discharged to the marine environment from product carriers in domestic trade and the effects of these discharges on the marine environment. Specific actions which should be undertaken are described below. Some of the efforts to gather information on degree of compliance with current discharge standards will also improve the degree of compliance. These actions, therefore, serve a dual purpose. Once some of these uncertainties regarding the need for and benefits of additional measures are eliminated, decision-making on any additional measures which might be appropriate can proceed on a much more rational basis than at present.

4. The Coast Guard should also continue and expand its program for boarding U.S. tank vessels in domestic trade at loading and discharge terminals. Experience indicates that observations of cargo transfer operations, material condition of the vessel, and Oil Record Books and official logs made by Coast Guard boarding teams during such visits can markedly improve the degree of compliance with regulations already in effect.

## RECOMMENDED ACTIONS TO REDUCE UNCERTAINTIES IN PRESENT AND PROJECTED OIL DISCHARGES AND EFFECTS OF DISCHARGES ON THE MARINE ENVIRONMENT

A number of actions were identified by this study which would add greatly to our knowledge about oil discharges from U.S. tankships and their effects on the marine environment. Many of these same actions would also promote compliance with the national and international discharge standards now in effect.(1) These actions are:

a. A program to gather better data on the amount of oil remaining aboard tankships on completion of cargo discharge, the amount of departure ballast used and how much waterwashing of cargo tanks is done, and the methods used for treating and disposing of oily mixtures created by ballasting and tank washing. This program should include an assessment of the degree of compliance with the oil discharge restrictions now in effect. Specific measures which should be considered as part of this program are field studies and observations on U.S. tankships, gathering information from tankship operators concerning ballasting and tank-cleaning policies and practices, joint government-industry seminar on operational pollution prevention techniques, analysis of information from violation reports and PIRS as an indication of "degree of compliance", special surveillance efforts to detect discharge violations, loading port inspections of U.S. tankships, review of completed Oil Record Books and official logs, and additional information gathering and analysis of facilities for the reception and treatment of oily wastes from vessels.

b. Further collection and analysis of information on location and extent of hull damage and oil outflow resulting from collision, ramming, and grounding accidents. This information is needed in order to provide a better assessment of various segregated ballast protective location design alternatives, such as double side, double bottom, or alternate wing tank designs, with different areas and depths of protection on the sides and botoom of tankships.

c. Continued efforts to understand the relationship between oil inputs and damage to the marine environment. The study indicates considerable additional information on oil inputs, fates, and effects and measuring economic impacts of oil pollution has been developed since the 1975 report by the National Academy of Sciences. A review and update of the NSA assessment should be conducted, since it is very difficult for an individual or even a whole agency to assemble, digest, and put into perspective all this information in a way that is useful in making policy decisions. It also appears that information on accidental oil discharges available from pollution incident reports makes worthwhile further effors to relate oil input reductions and environmental effects for U.S. tankers in domestic trade, perhaps as a cooperative R & D or staff effort among several of the agencies participating in this study.

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(1) Operational discharge standards now in effect are described on page 30 of the report.

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## APPENDIX A

## NOMENCLATURE

The following terms are used in this report discussing tankers and definitions are presented here for clarification:

CAA - Collision avoidance aids

CBT Clean ballast tanks, or dedicated clean ballast tanks

CHEMICAL TANKER - Chemical tanker means a ship constructed or adapted primarily to carry a cargo of noxious liquid substances in bulk and includes an "oil tanker" as defined in Annex I (of MARPOL 73) when carrying a cargo or part cargo of noxious liquid substances in bulk. (MARPOL 73, Annex II, Reg. 1(1)).

COW - Crude oil washing

CRUDE OIL TANKER - Crude oil tanker means an oil tanker engaged in the trade of carrying crude oil (MARPOL Protocol, Reg. 1 (28)).

DB - Double bottoms

DWT - Deadweight tonnage

GT - Gross tonnage

IGS - Inert gas system

IMCO - The Intergovernmental Maritime Consultative Organization

MARPOL 73 - The International Convention for the Prevention of Pollution from Ships, 1973

MARPOL Protocol - Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973

OIL TANKER - Oil tanker means a ship constructed or adapted primarily to carry oil in bulk in its cargo spaces and includes combination carriers and any "chemical tanker" as defined in Annex II (of MARPOL 73) when carrying a cargo or part cargo of oil in bulk (MARPOL 73, Annex I, Reg. 1(4).

PL or PL/SBT - Protective location of segregated ballast tanks

PRODUCT CARRIER - Product carrier means an oil tanker engaged in the trade of carrying oil, other than crude oil (MARPOL Protocol, Reg. 1(30)).

SBT - Segregated ballast tanks

SOLAS 74 - The International Convention for the Safety of Life at Sea, 1974

SOLAS Protocol - Protocol of 1978 Relating to the International Conference for the Safety of Life at Sea, 1974

TANK BARGE - The terms 'tank barge' means any tank vessel not equipped with means of self-propulsion. 46 CFR 30.10-65.

TANKSHIP - "The term 'tankship' means any tank vessel propelled by power or sail." 46 CFR 30.10-67.

TANK VESSEL - The term tank vessel is used in U. S. regulations and is generally equivalent to tanker. It includes both tankships and tank barges.

TANK VESSEL - "The term 'tank vessel' means any vessel especially constructed or converted to carry liquid bulk cargo in tanks." 46 CFR 30.10-69.

TSPP - Tanker safety and pollution prevention

APPENDIX B

1. "Oil Pollution of the Oceans; The President's Message to the Congress Recommending Measures to Control the Problem," Dated March 17, 1977. Released March 18, 1977. Weekly Compilation of Presidential Documents, Volume 13, Number 12, March 21, 1977, pages 408-409.

2. White House Press Release, released March 16, 1977. Fact sheet: on possible Federal Government actions the President is considering to deal with the problem of marine oil pollution caused by oil tankers

3. White House Press Release, released March 18, 1977. Fact sheet: on the President's message to Congress recommending actions to reduce maritime oil pollution

# Oil Pollution of the Oceans

***The President's Message to the Congress Recommending Measures To Control the Problem. Dated March 17, 1977. Released March 18, 1977***

*To the Congress of the United States:*

The recent series of oil tanker accidents in and near American waters is a grave reminder of the risks associated with marine transportation of oil. Though we can never entirely eliminate these risks, we can reduce them. Today I am announcing a diverse but interrelated group of measures designed to do so.

These measures are both international and domestic. Pollution of the oceans by oil is a global problem requiring global solutions. I intend to communicate directly with the leaders of a number of major maritime nations to solicit their support for international action. Oil pollution is also a serious domestic problem requiring prompt and effective action by the federal government to reduce the danger to American lives, the American economy, and American beaches and shorelines, and the steps I am taking will do this.

The following measures are designed to achieve three objectives: First, to reduce oil pollution caused by tanker accidents and by routine operational discharges from all vessels; Second, to improve our ability to deal swiftly and effectively with oil spills when they do occur; and Third, to provide full and dependable compensation to victims of oil pollution damage.

These are the measures I recommend:

• RATIFICATION of the International Convention for the Prevention of Pollution from Ships. I am transmitting this far-reaching and comprehensive treaty to the Senate for its advice and consent. This Convention, by imposing segregated ballast requirements for new large oil tankers and placing stringent controls on all oil discharges from ships, represents an important multilateral step toward reducing the risk of marine oil pollution. In the near future, I will submit implementing legislation to the Congress.

• REFORM of ship construction and equipment standards. I am instructing the Secretary of Transportation to develop new rules for oil tanker standards within 60 days. These regulations will apply to all oil tankers over 20,000 deadweight tons, U.S. and foreign, which call at American ports. These regulations will include:

—Double bottoms on all new tankers;

—Segregated ballast on all tankers;

—Inert gas systems on all tankers;

--Backup radar systems, including collision avoidance equipment, on all tankers; and

—Improved emergency steering standards for all tankers.

These requirements will be fully effective within five years. Where technological improvements and alternatives can be shown to achieve the same degree of protection against pollution, the rules will allow their use.

Experience has shown that ship construction and equipment standards are effective only if backed by a strong enforcement program. Because the quality of inspections by some nations falls short of U.S. practice, I have instructed the Department of State and the Coast Guard to begin diplomatic efforts to improve the present international system of inspection and certification. In addition, I recommend the immediate scheduling of a special international conference for late 1977 to consider these construction and inspection measures.

• IMPROVEMENT of crew standards and training. I am instructing the Secretary of Transportation to take immediate steps to raise the licensing and qualification standards for American crews.

The international requirements for crew qualifications, which are far from strict, will be dealt with by a major international conference we will participate in next year. I am instructing the Secretary of Transportation to identify additional requirements which should be discussed, and if not included, may be imposed by the United States after 1978 on the crews of all ships calling at American ports.

• DEVELOPMENT of Tanker Boarding Program and U.S. Marine Safety Information System. Starting immediately, the Coast Guard will board and examine each foreign flag tanker calling at American ports at least once a year and more often if necessary. This examination will insure that the ship meets all safety and environmental protection regulations. Those ships which fail to do so may be denied access to U.S. ports or, in some cases, denied the right to leave until the deficiencies have been corrected. The information gathered by this boarding program will permit the Coast Guard to identify individual tankers having histories of poor maintenance, accidents, and pollution violations. We will also require that the names of tanker owners, major stockholders, and changes in vessel names be disclosed and included in this Marine Safety Information System.

• APPROVAL of Comprehensive Oil Pollution Liability and Compensation Legislation. I am transmitting appropriate legislation to establish a single, national standard of strict liability for oil spills. This legislation is designed to replace the present fragmented, overlapping systems of federal and state liability laws and compensation funds. It will also create a $200 million fund to clean up oil spills and compensate victims for oil pollution damages.

• IMPROVEMENT of federal ability to respond to oil pollution emergencies. I have directed the appropriate federal agencies, particularly the Coast Guard and the Environmental Protection Agency, in cooperation with

state and local governments to improve our ability to contain and minimize the damaging effects of oil spills. The goal is an ability to respond within six hours to a spill of 100,000 tons.

Oil pollution of the oceans is a serious problem that calls for concentrated, energetic, and prompt attention. I believe these measures constitute an effective program to control it. My Administration pledges its best efforts, in cooperation with the international community, the Congress, and the public, to preserve the earth's oceans and their resources.

JIMMY CARTER

The White House,
March 17, 1977.

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Office of the White House Press Secretary

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THE WHITE HOUSE

FACT SHEET
ACTIONS TO REDUCE MARITIME OIL POLLUTION

The President is considering a series of possible Federal Government actions to deal with the problem of marine oil pollution caused by oil tankers. These include:

-- U. S. ratification of the International Convention for the Prevention of Pollution from Ships, 1973.

-- Regulatory action by the Department of Transportation to establish new U. S. standards for all tankers entering U. S. ports.

-- Submission to Congress of oil spill liability and compensation legislation.

-- The establishment of a U. S. Marine Safety Information System to identify tankers with long histories of poor maintenance, accidents and pollution violations.

BACKGROUND

The rash of oil tanker accidents which occurred this winter off our east and west coasts has brought home to us the serious risks which are involved in marine transportation of oil. Oil pollution threatens some of our most valuable natural resources -- the ocean, its living inhabitants, our beaches and our shorelines. Oil tanker accidents also endanger human lives, and oil pollution can jeopardize the economic security of millions of Americans who live in coastal communities.

In his Address to the Nation on February 2, the President recognized these risks and the need for timely government action to deal with the problem. In response to the President's concern, the Director of the Office of Management and Budget established an interagency Task Force to identify possible solutions.

The Task Force recommended to the President that he also consider action to reduce marine oil pollution caused by operational discharges from tankers. The Argo Merchant, the Sansinena and the Olympic Games have been the subject of much public concern. Such tanker groundings and collisions are a serious problem to the localities where they occur. However, they are not the major maritime source of ocean oil pollution. Operational discharges from oil tankers and other vessels cause a far greater total amount of oil pollution than accidents. Therefore, the actions which the President is considering deal with both problems.

THE INTERAGENCY OIL POLLUTION TASK FORCE

The Task Force was formed on February 3. The Office of Management and Budget chaired the group. The following agencies participated:

Department of State
Department of the Treasury
Department of Defense

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Department of Justice
Department of the Interior
Department of Commerce
Department of Transportation
Federal Maritime Commission
Environmental Protection Agency
Council on Environmental Quality
Federal Energy Administration

Subgroups developed proposed initiatives in five areas:

1. Ships and ship systems
2. Crew standards and training
3. Oil pollution liability and compensation
4. International conventions
5. Oil spill response.

The Task Force contacted representatives of more than twenty interested public organizations and several States to solicit their views and suggestions. The organizations included environmental groups, the oil and transportation industries, oil spill cleanup companies and maritime unions. The States included Alaska, California, Florida, Louisiana, Maine, Massachusetts, Oregon and Washington. The suggestions and views of all of these groups are being carefully considered.

OBJECTIVES

The President's program is designed to meet four objectives:

1. reduce oil pollution resulting from oil tanker accidents and operational discharges;

2. improve our ability to deal with oil spills when they do occur;

3. assure that any citizens damaged by oil spills are fully compensated for their losses; and

4. reorganize Federal oil pollution programs to make them simpler and more responsive.

APPROACH

Pollution of the oceans by oil is a global problem. The United States is an active participant in the Inter-Governmental Maritime Consultative Organization, an international forum sponsored by the United Nations to formulate programs to reduce vessel pollution and to ensure safety of human life and vessels. The President's international initiatives will involve working through this international agency, as well as bilateral discussions with major shipping nations, our trading partners and our neighbors. The President plans to communicate directly with the leaders of a number of major maritime nations to seek their support in this effort.

On the domestic front, the President is considering strong administrative actions to upgrade U. S. standards on all oil tankers entering U. S. ports, as well as on the crews manning them. He is also considering action to upgrade several Federal programs designed to prevent accidents and respond to spills, including Coast Guard's tanker examination program and information systems and Federal oil spill response capability.

White House staff and the Office of Management and Budget spent yesterday on Capitol Hill discussing possible solutions with Members of Congress with a special interest in this area and with their staffs. That process is continuing. We hope to have their recommendations incorporated into a final proposal to be announced on Friday.

# # #

MARCH 18, 1977

Office of the White House Press Secretary

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THE WHITE HOUSE

FACT SHEET

Actions to Reduce Maritime Oil Protection

The President today announced a series of recommended Federal Government actions to deal with the problem of marine oil pollution caused by oil tankers. These include:

- A call for a special international conference to discuss stricter standards for oil tanker construction, equipment and inspections.
- Regulatory action by the Department of Transportation to establish new U.S. standards for all tankers entering U.S. ports.
- A Coast Guard program to board and examine all foreign flag oil tankers entering U.S. ports.
- U.S. ratification of the International Convention for the Prevention of Pollution from Ships, 1973.

BACKGROUND

As announced on March 16, these measures are designed to deal with the problem of oil tanker accidents and spills which occurred so frequently in and near U.S. waters this winter. The recommended actions will also serve to reduce oil pollution caused by operational discharges from tankers.

The President plans to communicate directly with the leaders of a number of major maritime nations to seek their support for strengthened international solutions to this world-wide environmental problem. The United States will also continue to participate actively in the Inter-Governmental Maritime Consultative Organization, a special United Nations agency, to formulate new programs to reduce vessel-source oil pollution.

The President's domestic program is strong and comprehensive. It includes both administrative and legislative actions and meets all four of the President's objectives - reduction in tanker pollution, improvements in oil spill response, assuring compensation of damaged citizens, and reorganization of government programs.

The recommended actions were formulated after consultation with environmental groups, the oil and transportation industries, oil spill cleanup companies and maritime unions. In addition, the suggestions and views of coastal States were solicited.

THE PRESIDENT'S PROPOSALS

1. The International Convention for the Prevention of Pollution from Ships, 1973

   The President will transmit this important International Convention to the Senate for its advice and consent and will submit implementing legislation next month for Congressional approval. The United States was a leader in the development of this Convention, commonly known as the 1973 Marine Pollution Convention. It is a far-reaching and comprehensive agreement which will have an important impact on marine oil pollution.

   The Convention places stringent controls on oil discharges from ships, including for the first time, discharges of light refined petroleum products. It requires segregated ballast

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for all new tankers 70,000 deadweight tons and over, as well as oil discharge monitoring and control equipment, and sets requirements for cargo tank size and arrangement to limit oil spills in case of accident. In addition, the ports of signatories to the Convention will be required to have reception facilities for tankers' oily wastes.

2. Ship Construction and Equipment Standards

The President is directing the Secretary of Transportation to issue within 60 days proposed rules for a series of new oil tanker standards, and, as provided by law, to expedite the necessary regulatory procedures. The proposed regulations will apply to all oil tankers, U.S. and foreign, over 20,000 deadweight tons entering U.S. ports. They will include:

1. Double bottoms on all new tankers.
2. Segregated ballast on all tankers.
3. Inert gas systems on all crude tankers.
4. Backup radar systems with collision avoidance equipment on all tankers.
5. Improved emergency steering standards for all tankers.

These requirements would take full effect within five years. The rules should allow the adoption of technological improvements and alternatives which can be shown to accomplish equivalent pollution protection.

The President especially acknowledges the leadership of Senator Warren G. Magnuson and the Senate Commerce Committee on matters relating to tanker safety. All of the initiatives outlined above are the kinds of solutions the Committee has endorsed over a period of years.

Ship construction and equipment standards are not effective unless coupled with a strong enforcement program. Therefore, the President is directing the Department of State and the Coast Guard to begin diplomatic efforts to upgrade the present international system of inspection and certification. Construction and equipment inspections are carried out by all maritime nations. However, the quality of inspections by some nations falls far below U.S. practice.

In addition the United States will propose the immediate scheduling of a special international conference for the early fall to consider these construction and inspection measures. The U.S. will recommend that technical preparatory work be done by the Inter-Governmental Maritime Consultative Organization this spring and summer to ensure effective international action.

Authority for the domestic action is provided by the Ports and Waterways Safety Act of 1972 (Public Law 92-340) which provides the Department with a broad mandate to protect U.S. waters against pollution. These standards will reduce pollution through both accident prevention and reduction in operational discharges. A description of these requirements follows:

Double bottoms reduce oil spills caused by tanker groundings. Studies of groundings conclude that in 45 to 90 percent of cases no oil outflow would have occurred if the tank vessel had had a double bottom. The requirement will apply only to new vessels. Double bottoms can also be used for a part of the required segregated ballast space.

Segregated ballast provides tanks dedicated exclusively for the seawater which is carried by empty oil tankers for ballast. The use of separate clean tanks means that no oil is discharged along with ballast water. Deballasting and associated tank washing is the major source of operational oil pollution from tankers. Ballast tanks on new tankers can also be arranged to provide protection against oil outflow in case of accident.

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The 1973 Marine Pollution Convention marks the international community's acceptance of the concept of segregated ballast. Coast Guard regulations currently require the system on all new tankers over 70,000 deadweight tons, foreign and domestic. The rulemaking proposed today also covers existing tankers. These vessels can achieve segregated ballast capability by dedicating certain cargo tanks to ballast and modifying piping and pumps.

Inert gas systems reduce the danger of explosions which may occur at times when oil tanks are not full, primarily during tank washing, but also in loading and unloading, and during ballast voyage. The Sansinena, which exploded in Los Angeles harbor in December while taking on ballast, had no inert gas system.

Current U.S. regulations require the system for new U.S. tankers over 100,000 deadweight tons. The proposed rule will also apply to existing tankers and foreign flag vessels.

Backup radar systems provide redundant capacity in case of equipment failure. Collision avoidance equipment can be programmed to automatically process radar information and to trigger an alarm when dangerous situations arise. The equipment also provides information to the crew for maneuvering to avoid the potential danger. The systems are most effective in the coastal confluence zone where vessel traffic patterns converge toward U.S. ports. The requirement will apply to both new and existing vessels and would be effective for existing vessels within 2 years of final rulemaking.

Improved emergency steering standards will be drafted. Current regulations impose redundancy requirements for some components of tanker steering gear. Additional requirements which would further improve reliability have been identified.

3. Crew Standards and Training

The President is ordering several actions to improve the qualifications of crews that man oil tankers entering our ports. These actions are particularly crucial because human error is involved in 80-85 percent of all tanker accidents. The United States imposes relatively strict standards for the U.S. Merchant Marine, but stringent international requirements for crew qualifications do not exist. However, the Inter-Governmental Maritime Consultative Organization is developing a major draft convention on the subject for negotiation next year. The President views this effort as a major international opportunity to upgrade crew qualifications. The President is directing the Departments of Transportation and Commerce to review the agenda (the draft convention) for the 1978 Conference on Standards of Watchkeeping and Training to identify additional requirements which should be proposed for consideration. In addition, the Department will identify all requirements which, if not included in the 1978 Convention, the U.S. should impose on crews of all ships entering U.S. ports.

Nationally, the President is directing Transportation to take immediate regulatory action to improve standards for U.S. crews. Requirements will include experience by class and size of vessel, or training and demonstration of proficiency on ship simulators. These requirements will apply to both issuance and renewal of licenses to ships masters, mates and Federally licensed pilots. More emphasis will be placed on requiring deck officers to demonstrate important skills, such as radar operation and interpretation, instead of relying on written examinations. Finally, regulations will be issued to require that crew members in charge of cargo transfer operations be specially trained and examined.

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4. Tanker Boarding Program and U.S. Marine Safety Information System

The President is directing that, starting immediately, each foreign flag tanker which enters U.S. ports will be boarded by the Coast Guard and examined to insure that the ship meets all safety and environmental protection regulations. Tankers will be boarded at least once a year and more often if necessary. Any deficiencies in the tanker's condition will be required to be corrected. This winter the Coast Guard began a limited foreign tanker boarding program. The President's revisions to the Budget for the next fiscal year requested additional funding for this program.

The information which is gathered from the boarding program will be fed into a U.S. Marine Safety Information System, which will be established to keep track of the accident and pollution records of all ships, U.S. and foreign, entering U.S. ports. Coast Guard information systems already contain some of this information for U.S. vessels. Since 94% of our imported oil enters the country in foreign tankers, it is important that information on these vessels also be available to Captains of the Port at all major U.S. ports. The President is also directing that the proper Federal agencies initiate action to require that the names of tanker owners, major stockholders, and changes in vessel names be disclosed and be made available for inclusion in the Marine Safety Information System. This system will enable the Coast Guard to promptly identify tankers which have long histories of poor maintenance, pollution violations and accidents. Once identified, such tankers can be excluded from U.S. ports, if necessary.

5. Comprehensive Oil Pollution Liability and Compensation Legislation

The Secretary of Transportation will submit to Congress on the President's behalf the Comprehensive Oil Pollution Liability and Compensation Act of 1977, which replaces the current fragmented and overlapping systems of Federal and State oil spill liability laws and compensation funds with a single nationwide framework. It establishes one national standard of strict liability for oil spills whether the source be vessels, pipelines, terminals or offshore facilities. It also establishes a $200 million fund to cover cleanup costs and to assure full compensation to victims for virtually all oil pollution damages. The fund consolidates three existing Federal oil pollution compensation funds, the Trans-Alaska Pipeline Fund, the Deepwater Ports Fund and part of the Federal Water Pollution Control Act Fund. The compensation provided under the legislation is extensive. For example, eligible claimants include fishermen whose usual fishing grounds are polluted and resort communities whose peak vacation seasons are ruined by oil-slicked beaches.

The Administration bill is based on legislation which has been introduced by Congressmen Murphy and Biaggi and is now under consideration by the House Merchant Marine and Fisheries Committee. The Administration bill raises the minimum liability for vessels carrying oil in bulk to $300,000 and removes the $30 million ceiling on liability for supertankers. It also proposes a mechanism for States to participate in the Federal compensation system. Another change will allow the Fund to provide compensation to Federal and State agencies which perform post-spill environmental damage assessments.

6. Federal Oil Pollution Response Capability

The President is directing the Coast Guard, the Environmental Protection Agency, and other responsible Federal agencies to begin plans for upgrading their capability to respond to, contain,



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and mitigate the damaging effects of oil spills in cooperation with State and local governments. Special attention will be given to spills which occur under extreme weather conditions.

The framework for coordination of Federal pollution response activities is established by the National Contingency Plan (40 Federal Regulations 1510). The Coast Guard and the Environmental Protection Agency are the lead agencies under the plan. In their assigned areas of responsibility, each agency predesignates Federal on-scene coordinators who are responsible for directing the Federal response when oil spills occur. The National Plan is supplemented by Regional Response Plans, which provide for coordination of Federal, State and local government response efforts. This response system, particularly the Regional Plans, will be reviewed as part of the President's oil pollution program.

Presently the Coast Guard can deliver pollution containment and cleanup equipment to the scene of a spill within 24 hours. The Administration plans to evaluate the costs and feasibility of upgrading this capability to provide adequate response within six hours for a spill of up to 100,000 tons of oil.

ADDITIONAL INITIATIVES

Along with the major actions just discussed, the President is directing the Secretary of Transportation, in cooperation with the Environmental Protection Agency and other appropriate agencies, to undertake several studies of other promising programs and techniques for reducing marine oil pollution. These studies will include:

- An evaluation of the costs and benefits of crude washing, a system which utilizes crude oil to clean cargo tanks.
- An evaluation of design, construction and equipment standards for tank barges which carry oil.
- A study of long range vessel surveillance and control systems.
- An evaluation of devices to improve maneuvering and stopping ability of large tankers, with research to include the use of ship simulator.
- A study of the fee collection mechanism for the comprehensive oil pollution fund.

The Secretary of Transportation will report back to the President after 6 months on the status of these studies.

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APPENDIX C

# ANALYSIS PROCEDURES FOR DETERMINING IMPACT ON THE MARINE ENVIRONMENT

## PROBLEM ANALYSIS

A statement of the hazard represented by events leading to damage to the marine environment must consist of at least three elements:

X vessel is involved in

Y event at

Z location

The vessel may be characterized by type, route, size, and cargo as shown in Table 2. The event may be either an accident event or a routine operations event as shown in Table 3. Damage to the marine environment is strongly dependent on the location where a vessel is involved in an event. The location can be specified in terms of its proximity to the shoreline or specific items that might be affected by oil outflows or hydrocarbon air emmissions as indicated in Table 4.

Specific hazards may be identified and defined by using an X, Y, and Z factor from Tables 2, 3, and 4. Specific examples with which this study is concerned are shown in Table 5.

Table 5 represents the two most significant ways it is possible for U. S. tankers in domestic trade to contribute to damage to the marine environment.

In order to estimate what environmental effects these hazard scenarios may have it is necessary to estimate how much oil is currently being discharged to the marine environment as a result of (1) Accidents to U. S. tankships in domestic trade, and (2) Operations of U. S. tankships in domestic trade. Once estimates of amounts of oil imports from these sources are made, then these estimates must be related to damage to the marine environment.

Table 2

"K" Factors Characterizing the VESSEL
(U.S. Tankers in Domestic Trade)

| Vessel Type | Route | Size | Cargo | Remarks |
|---|---|---|---|---|
| Tankship (includes integrated tug/barge) | Ocean | 1000 GT-4000 DWT | Crude | None used for crude oil |
| | | | Product | 9 vessels |
| | | 16,000 DWT-40,000 DWT | Crude | 17 vessels (now) |
| | | | Product | 119 vessels (now) |
| | | 40,000-70,000 DWT | Crude | 19 vessels |
| | | | Product | 12 vessels |
| | | over 70,000 DWT | Crude | 36 vessels |
| | | | Product | 1 vessel |

Table 2 (Cont'd)

"X" Factors Characterizing the VESSEL
(U.S. Tankers in Domestic Trade)

| Vessel Type | Route | Size | Cargo | Remarks |
|---|---|---|---|---|
| Tank Barge | Ocean | all sizes | Crude & product | 193 vessels |
| | Coastwise | all sizes | Crude & product | 127 vessels |
| | Lakes, Bays, Sounds, Rivers | all sizes | Crude & product | 2318 vessels |

Table 3
"Y" Factors Characterizing the EVENT

| Event | Remarks |
|---|---|
| Accident Events | |
| * Collision, ramming, grounding | |
| Flooding, capsizing, foundering | few incidents, usually at sea |
| * Fire/explosion | cargo often burns rather than cause oil pollution |
| * Structural failure | largest single source, usually occurs on high seas in bad weather |
| Personnel injury | usually doesn't result in oil outflow |
| Breakdown | only if concern if it results in another casualty causing hull rupture |
| Cargo transfer mishap | relatively minor source of oil inputs |

(Note: Events indicated by(*)often involve hull damage and oil outflow.)

| | |
|---|---|
| Routine Operations Events | |
| Oily mixtures | |
| Cargo oil discharges | |
| From Cargo Oil tanks (refer to Table 3a for description of circumstances leading to discharge from cargo oil tanks) | |

Table 3 (cont'd)
"Y" Factors Characterizing the EVENT

From Pumproom Bilges

Machinery space discharges

Engineroom bilges

Fuel and lube oil purifiers

Tanker gaseous emissions

Marine boiler flue gases

Hydrocarbon evaporation losses

Solid wastes

Tanker/cargo sediments

Garbage

Sanitary wastes (Sewage)

Miscellaneous tanker discharges

Inert gas system flue-gas-scrubber effluent

Boiler water blowdown

Miscellaneous oil discharges

Main deck drains

Drippings from deck machinery

Table 3a
Circumstances leading to discharge from cargo oil tanks

| | |
|---|---|
| Discharges from tank vessel cargo oil tanks arise from the following set of circumstances: | |
| 1. Some oil remains in cargo tanks after discharge of cargo (Pipeline clingage and retainment) | Amount of oil left in the vessel can be reduced through better stripping, better piping system design, better operating practices, and COW |
| 2. Water is introduced into the vessel and mixed with oil left on board | |
| a. Dirty cargo tanks are ballasted to provide departure ballast | determined by amount of departure ballast needed, avoided by SBT, DCBT |
| b. Dirty cargo tanks are water washed to provide space for clean saltwater ballast | determined by amount of clean arrival ballast needed, avoided by SBT, DCBT |
| c. Dirty cargo tanks are water washed to remove sediment which settles out of cargo (routine cleaning to keep down sediment) | |
| d. Dirty cargo tanks are water washed to remove cargo residue and sediment to avoid contamination of next cargo | usually confined to product carriers, not always necessary |
| e. Dirty cargo tanks are water washed to remove cargo residue and sediment (and then ventilated until gas-free) to eliminate explosion hazard on the ballast voyage | |
| f. Dirty cargo tanks are water washed to remove cargo residue and sediment prior to entering shipyard for repair work | Normally required at 18 month to 2-year intervals |

| Table 3a (cont'd) Circumstances leading to discharge from cargo oil tanks | |
|---|---|
| 3. The <u>oily mixtures</u> (defined as mixtures with any oil content) created are disposed of in one or more of the following ways: | |
| a. They are discharged directly overboard without any effort to separate the oil from the water and retain the oil on board. | Limitations on the discharge of oil found in FWPCA, 40 CFR 110, 1969 Amendments to 1954 Convention, and 33 CFR 157 prohibit discharge of oily mixtures in most cases |
| b. All oily mixtures are retained on the vessel and discharged in port to a reception facility for oily wastes. | Depends on the availability of adequate reception facilities in the ports the vessel uses |
| c. Treat oily mixtures on the vessel to separate the oil from the water. Discharge the water and oily mixtures meeting applicable discharge criteria. Retain the rest on board to mix with next cargo if compatible or transfer to reception facility for reuse or disposal ashore. | Effectiveness depends on treatment processes and equipment utilized on the vessel and availability of adequate reception facilities or ability to mix retained oily mixtures with next cargo. |

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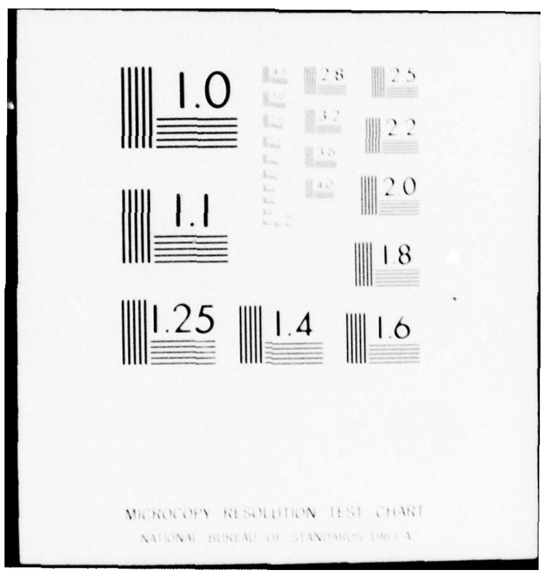
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1.4
1.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Table 4
"Z" factors characterizing the LOCATION

| Location | Remarks |
|---|---|
| Open Ocean, over 50 miles from shore | |
| Ocean, in vicinity of exposed shoreline | |
| Rocky shore | |
| Sandy beach | |
| Vicinity of coastal inlet or estuary | |
| In river or waterway | |
| In harbor | |
| **Supplemental factors** | |
| Proximity to shellfish beds, other fisheries resources | |
| Proximity to human population concentrations | factor in fire/explosion effects |
| Proximity to high value property susceptible to fire/explosion damage | factor in fire/explosion effects |
| Proximity to yacht harbors, marinas | fouling of boats |
| Proximity to recreational beach areas | fouling of beaches |
| Proximity to wetlands, saltmarsh, etc | biological impact, difficult to clean up |

Table 4 (cont'd)
"Z" factors characterizing the LOCATION

Note: The "Z" factors influence the impact of accidental oil discharges in a number of ways:

proximity to cleanup forces

vulnerability of valuable resources

confinement of spilled oil (Move out to sea or confined to small area)

currents and winds, carry oil to shore or to area where vulnerable resources are located

Location factors may also influence the liklihh likelihood of having a vessel accident:

collisions may depend on waterway configuaration, other traffic, speed of vessels at that location

groundings may depend on waterway configuation, water depth, bottom condition, speed of vessels

rammings may depend on waterway configuzation, pier design, current, wind, speed of vessel

Table 5
Hazard scenarios of particular interest--U. S. tankships in domestic trade

| VESSEL (Table 2) | EVENT (Table 3) | LOCATION (Table 4) |
|---|---|---|
| Tankships, Ocean routes, 5,000-40,000 DWT Product carriers (119 vessels) | Collision, ramming, grounding accidents | Coastal waters, harbor and harbor entranceway |
| | Cargo oil discharges as a result of routine operations--see Table 3a for specifics | U. S. coastal waters, but not limited to 50 miles offshore |
| Tankships Ocean routes 5,000-40,000 DWT Crude carriers transporting OCS oil to shore | Collision, ramming, grounding accidents | Coastal waters, harbor and harbor entranceway |
| | Cargo oil discharges as a result of routine operations-- see Table 3a for specifics | U. S. coastal waters, but not limited to 50 miles offshore |

ESTIMATE OF OIL INPUTS FROM ACCIDENTS TO U. S. TANKSHIPS IN DOMESTIC TRADE

In order to get some idea of the amount of oil currently being discharged to the marine environment as a result of collision, ramming and grounding accidents (i.e., the first scenario of Table 5), data from the Coast Guard Pollution Incident Reporting System (PIRS) were used to develop Tables 6 and 7.

Table 6 presents data on numbers of collision and ramming incidents and numbers of grounding incidents and resulting oil inputs to the environment for each of the years 1973 through 1976.

Table 7 provides information on the location where these oil inputs took place.

Annual averages over these four years are:

9 collisions and rammings per year with a total quantity 650 metric tons of oil outflow, per year, and

6 groundings per year with a total quantity 639 metric tons of oil outflow per year.

While one must be extremely careful about averages of oil outflow amounts since the size of individual spills ranges so widely, it is believed that these figures do provide some overall measure of the magnitude of the problem of accidental oil inputs from U. S. tankers. (These figures overstate the problem due to U. S. product tankers, 16,000-40,000 dwt, slightly since they include U. S. tankers of all sizes, crude as well as product, and include vessels not in domestic trade.)

Assuming that fleet size and composition amounts and routes of oil movements, quality of crew training and performance, (and a host of other things that may well be changing with time) remain constant, these averages also represent some measure of the total possible impact of a measure of group of measures which would be 100% effective in eliminating oil inputs to the marine environment as a result of accidents involving U. S. tankships in domestic trade.

The impact on oil inputs of any measure or group of measures actually implemented could be expected to be less than this maximum theoretical impact depending on how effective they were.

Table 7 seems to indicate that most of the oil inputs recorded for 1973-1976 took place in harbor and port areas. (It should be noted that only pollution incidents identified by vessels are included in this table, and that spill detection, reporting, and source identification are probably more complete in harbor and port areas than the other areas. These factors may account for some missing reports in territorial sea, contiguous zone, and high seas, although it would be difficult to avoid reporting a spill of any size associated with a collision or grounding.)

Table 6

Oil inputs from U.S. tankships (of all sizes)
in U.S. waters (within 50 miles of U.S. shoreline)
1973-1976 Pollution Incident Reporting System (PIRS) data

| Calendar Year | Collision & ramming<br>no incidents/metric tons of outflow | Grounding<br>no. of incidents/metric tons of outflow | All types of pollution incidents<br>no./metric tons of oil outflow |
|---|---|---|---|
| 1973 | 8/295 | 10/819<br>(incl. 1/631) | 347/1430 |
| 1974 | 9/69 | 6/18 | 394/294 |
| 1975 | 14/1930<br>(incl 1/1610) | 6/1716<br>(incl 1/1610, 1/103) | 308/3927 |
| 1976 | 5/303<br>(incl 1/270) | 2/2.7 | 235/1146 |
| Totals | 36/2596 | 24/2556 | 1284/6797 |

Notes:

1. This table includes all pollution incidents detected by or reported to the U. S. Coast Guard and recorded in the USCG Pollution Incident Reporting System which have been identified by vessel.

2. Discharge quantities reported in gallons in PIRS data have been converted to metric tons using a specific gravity of 0.85.

Table 7

Location of accidental oil discharges from U.S. tankships (of all sizes) in U.S. waters (within 50 miles of U.S. shoreline)
1973- 1976 Pollution Incident Reporting System (PIRS) data

| LOCATION | Collision and ramming (no. incidents / metric tons of oil outflow) | Grounding (no. of incidents / metric tons of oil outflow) |
|---|---|---|
| Harbor and port areas [3] | 34 / 2577 | 23 / 2554 |
| Territorial sea (baseline to 3 miles) | 0 / 0 | 1 / 632 |
| Contiguous zone (3 to 12 miles) | 0 / 0 | 0 / 0 |
| High seas (12 to 50 miles) | 2 / 6005 | 0 / 0 |
| Totals | 36 / 2596 | 24 / 2556 |

Notes:

1. This table includes all pollution incidents detected by or reported to the U.S. Coast Guard and recorded in the USCG Pollution Incident Reporting System which have been identified by vessel.
2. Discharge quantities reported in gallons in PIRS data have been converted to metric tons using a specific gravity of 0.85.
3. "Harbor and Port Areas" includes bays, estuaries, sounds, river areas, channels and other restricted waterways, port and harbor areas including terminals and docks, and beaches and shore areas adjoining these waters.

In order to better assess the effectiveness of various specific measures in eliminating or controlling these oil inputs, additional work is required to obtain and document information on the specific incidents which make up the totals shown in Tables 6 and 7. This effort will also provide additional information on location, clean-up costs, and environmental effects of these past spill incidents.

## ESTIMATE OF OIL INPUTS FROM OPERATIONS OF U. S. TANKSHIPS IN DOMESTIC TRADE

How much oil is currently being discharged to the marine environment as a result of routine operation of U. S. tankships in domestic trade (specifically, the second scenario in Table 5)?

Efforts to answer this question must start with consideration of the "Routine Operation's Events" in Table 3. We are concerned primarily with "cargo oil discharges from cargo tanks." (While discharges from pumproom bilges, machinery space discharges, tanker gaseous emissions, sewage, and the other miscellaneous tanker discharges are of concern, discharges from cargo oil spaces are the primary problem of concern here.)

As Table 3a indicates, the amount of oil discharged from a tank vessel's cargo oil depends on:

. the amount of oil which remains in the cargo tanks after discharge of cargo is completed,

. the amount of departure ballast (dirty ballast) used and how much waterwashing of cargo tanks is done, and

. the methods used for disposing of the oily mixtures created by ballasting and tank washing.

The total amount of oil discharged over some period of time by a <u>fleet</u> of tankships would depend on the above factors for each vessel plus the total amount of oil moved by these ships. Estimates of the total quantity of oil discharged will depend on these factors, which will each be discussed in turn.

1. <u>Some oil remains in cargo tanks and cargo piping system after discharge of cargo</u>.

Reference (a) states:

"A tanker discharges its cargo at the unloading port through large cargo lines and smaller stripping lines. At the end of this unloading operation, oil remains in the pipelines. Typically, the larger cargo lines are drained into a tank where the stripping pumps are employed to send as much of the oil as possible ashore. This procedure is followed

to maximize the oil received by the refinery and to minimize the amount retained in the ship's tanks and pipelines. If there is any remaining oil in the stripping lines, it is diverted to either the slop tank or another empty tank. At this point, both the cargo and stripping lines are then flushed into the slop tank. If this sequence of operations is executed properly, very little oil is retained in the pipelines; thus eliminating a major potential source of oil discharge when these pipelines are utilized later in the voyage to discharge ballast water. If for any reason ships do not drain and flush the lines completely, oil pockets may remain in some sections of the pipelines. This incomplete draining naturally increases the quantity of oil that has the potential of ending up in the sea." (page 29).

Reference (b) reports results of a field study of the disposition of oily residues from "light-oil" product tankers made in 1972-1973 aboard two U. S. product tankers.

This study indicated that the cargo remaining on board after discharge on these two vessels ranged from 0.06 - 0.10 percent of the total cargo carried. In both cases, the majority of the oil residue was in the cargo piping system (75-88% of the total residue) with only some 0.007 - 0.026 percent of the total cargo carried remaining in the tanks themselves. Oil puddles in the bottom of the tanks around the cargo piping suction bellmouths were believed to account for as much as 80 percent of the oil remaining within the tanks. Oil clingage on the cargo tank walls accounted for the smallest portion of the total oil remaining on board.

Table 8 summarizes the results of these field studies. On the basis of these studies, the authorities of reference (b) concluded that if the oil contained in the cargo piping system and the oil pools or puddles around the suction bellmouths can be retained on board the ship or discharged to a reception facility ashore, the remaining oily mixtures may be discharged in compliance with the discharge limits contained in the '69 Amendments, MARPOL 73, and 33 CFR 157 (both limits on total quantity and rate of discharge). Observations also indicated that settling time required to separate the light oil from the water column appears to be on the order of one day or less and recovery of the oil remaining on board after cargo discharge could be improved significantly through improved stripping pump efficiency, effecient clearing of cargo piping system, and internal coating of cargo tanks.

2. Water is introduced into the vessel and mixed with oil left on board

a. Dirty cargo tanks are ballasted to provide departure ballast.

b. Dirty cargo tanks are water washed to provide space for clean saltwater ballast.

Table 8

Sources of cargo oil residues left on board product oil tankships after cargo discharge (data from ref b)

| Tankship and cargo | oil remaining on board as % of total cargo carried | oil in cargo piping as % of total cargo carried | oil in "puddles" in cargo tanks as % of total cargo carried | oil clinging to tank walls as % of total cargo carried |
|---|---|---|---|---|
| USNS AMERICAN EXPLORER (JP-4) | 0.06 % | 0.048 % | 0.0055 % | 0.0014 % |
| SS CATIGNY (Navy Distillate Fuel Oil) | 0.10 % | 0.076 % | 0.020 % | 0.005 % |

Notes:

1. This table was developed from results of field studies aboard two U.S. flag product carriers reported in reference b.

Dirty Ballast Water - After discharging its cargo oil at the unloading terminal, a tanker places various amounts of ballast water (usually sea water) from the harbor into the empty cargo tanks to provide stable conditions. The quantity of ballast water required by a specific ship depends upon its construction and the prevailing weather and sea conditions. Under normal circumstances, between 20 and 35 percent of vessel's cargo capacity must be filled with ballast for a safe voyage. On rare occasions in rough seas and harsh weather conditions, a tanker may require ballast of between 50 and 75 percent of its cargo capacity.

This harbor water is termed dirty ballast because it comes in contact with oil residues present in the empty and dirty cargo tanks during the ballasting operation at the unloading terminal. Since many worldwide loading ports do not have facilities to handle or treat this dirty ballast water, it is discharged in the open sea prior to arrival at the loading terminal. Tankers practicing careful pollution control measures will discharge only the settled ballast water (the remaining oil/water mixture is transferred to the slop tank) whereas ships not practicing controlled procedures will discharge all of the oily ballast at sea.

Clean Ballast Water - Upon completing tank washing operations, a tanker pumps fresh sea water into the cleaned compartments. The water in these tanks is referred to as clean ballast. When a tanker arrives at the loading terminal, it discharges the clean ballast into the harbor as it receives the cargo oil. In many cases, there is very little free oil associated with this ballast water so it does not produce a sheen on the water's surface. The amount of free and dissolved oil present in the ballast is a function of the effectiveness of the tank cleaning operation and the intrinsic oil content level in the ocean water.

Permanent (Segregated) Clean Ballast Water - In order to reduce the amount of dirty ballast water on a tanker, newer tankers and some older ships have been fitted with segregated ballast systems. The pipelines, pumps and tanks are segregated from the cargo and stripped systems. Therefore, unless physical damage (such as valve leaks or bulkhead cracks) occur, no oil should come in contact with the water pumped aboard at the loading port. The presence of segregated ballast reduces the quantity of dirty ballast needed to keep the tanker stable. This in turn reduces the quantity of oil that is discharged during the deballasting operation.

c. Dirty cargo tanks are water washed to remove cargo residue and sediment which settles out of cargo (routine cleaning to keep down sediment).

This necessary for crude oil. It may also be necessary for product carriers carrying residual fuel oil and some other dirty products. It should not be required on ships carrying refined products (gasoline, diesel fuel, jet fuels, etc.) On most product carriers we expect little or no tank washing solely for routine sediment removal.

d. Dirty cargo tanks are water washed to remove cargo residue and sediment to avoid contamination of the next cargo.

Reference (2) indicates:

"Unlike tankers in the crude oil trade who will on an average clean 30-40% of their tanks on each ballast voyage to provide for clean ballast, product tankers are required to clean all or a greater percentage of cargo tanks during the ballast voyage. This is because of the uncertainty of what the next oil cargo will be and the concern for contamination of the following cargo by the residues of the previous one. Even when the same type oil is to be carried or when the new cargo is compatible with the old, tank cleaning or flushing is still often performed to eliminate explosion hazards and to provide for clean ballast. The literature indicates that light oil tankers will wash an average of 75 percent of the cargo tanks during each ballast voyage."

e. Dirty cargo oil tanks are water washed to remove cargo residue and sediment (and then ventilated until gas-free) to eliminate explosion hazard on the ballast voyage.

f. Dirty cargo tanks are water washed to remove cargo residue and sediment (and then ventilated until gas-free) to eliminate fire and explosion hazard prior to entering shipyard for repair work.

This is normally a very thorough cleaning of the entire vessel carried out at 18-month to 2-year intervals.

3. The oily mixtures created are disposed of in one or more of the following ways:

a. They are discharged directly overboard without any effort to separate the oil from the water and retain the oil on board.

Limitations on the amount of oil which may be discharged will make this a violation of law or regulation in most cases:

The Federal Water Pollution Control Act and 40 CFR 110 prohibit the discharge of any oily mixture which will leave a sheen into U. S. navigable waters and the contiguous zone.

The 1969 Amendments to the 1954 Oil Pollution Convention and 33 CFR 157 prohibit all discharges of oily mixtures from cargo tanks within 50 nautical miles of the nearest land and require that vessels discharging oily mixtures from cargo tanks outside of 50 miles comply with the following conditions:

(1) vessel is proceeding enroute

(2) discharging at an instantaneous rate of oil content not exceeding 60 liters per nautical mile

(3) the total quantity of oil discharged into the sea does not exceed 1/15,000 of the cargo carried for existing vessels and 1/30,000 for new vessels.

Assessment of what portion of the total discharges are due to direct discharge of oily mixtures overboard by U. S. tankships in domestic trade is really a question of "to what extent are U. S. tankships in domestic trade complying with the discharge standards now in effect?" There appears to be little if any direct evidence on which to base some inference about the degree of compliance with the discharge standards. Possible sources of information on which to draw some inference include:

1. number of tankships cited for discharges in volation of the discharge limits,

2. occurrence of oily deposits (slicks, tarballs, etc.) in areas with high traffic by U. S. tankers in domestic trade. (How do you know the oil comes from discharges from U. S. tankships in comestic trade and not from cargo ships, or tankships in foreign trade?)

3. Direct observation (most likely by aerial surveillance) of tankships discharging oily mixtures in violation of the discharge standards.

4. tankships arriving in a loading port without any cargo residues or oily mixtures on board. This would seem to indicate the vessel had discharged these residues and mixtures at sea (in violation of the discharge standards) rather than retaining them on board.

b. All oily mixtures are retained on the vessel and discharged in port to a reception facility for oily wastes.

c. Treat oily mixtures on the vessel to separate the oil from the water. Discharge the water and oily mixtures meeting the applicable discharge criteria. Retain the rest on board to mix with next cargo if compatible or transfer to reception facility for reuse or disposal ashore.

Again, direct evidence about how many vessels are now using each of these options is scarce. Possible sources of information on which to base some inference include:

1. Comparison of the location and capacity of known reception facilities to the capacity required for various portions of the fleet of U. S. tankers in domestic trade to be able to use these options.

2. Information on the operating procedures and policies in use by oil shippers, including amounts of oily mixtures received at reception facilities. (What do they say they are doing?)

3. Information gleaned from a review of Oil Record Books for U. S. tankships in domestic trade. (Are these books being properly kept as required by 33 CFR 151.35? Are the books for vessels not engaged in foreign voyages being submitted during the month of April and October to the Coast Guard as required by 33 CFR 151.35(h)? Is information recorded adequate to draw some inference concerning amounts of ballast and tank washing done, extent of use of reception facilities, discharges made at sea, etc.? What inferences can be drawn on those questions?)

On the basis of the factors discussed above, an estimate of the operational oil inputs from U. S. tankers in domestic trade may be made. Results of calculations are summarized in Table 9 and Figure 3, and supporting calculations are shown on the following pages.

A key variable in these assessments is uncertainty over the degree of compliance with current operational discharge restrictions. Estimates of current discharges range as high as 80,000 or as low as 6000 metric tons per year, depending on what degree of compliance is assumed.

Ways of reducing the uncertainties inherent in this estimate are discussed on the preceeding page.

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Table 9

Estimated oil inputs from accidents and operations of U.S. tankships, 5,000 DWT - 40,000 DWT, in domestic trade, 1985

| Source | Estimated oil inputs metric tons/year | |
|---|---|---|
| Accidental inputs | | |
| Collisions and rammings | 9 incidents / 650 tons | |
| Groundings | 6 incidents / 640 tons | |
| Operational | "good" practice | "bad" practice |
| "white" product | 3,680 | 39,930 |
| "black" product | 920 | 14,160 |
| Total oil inputs | 5,890 | 55,380 |

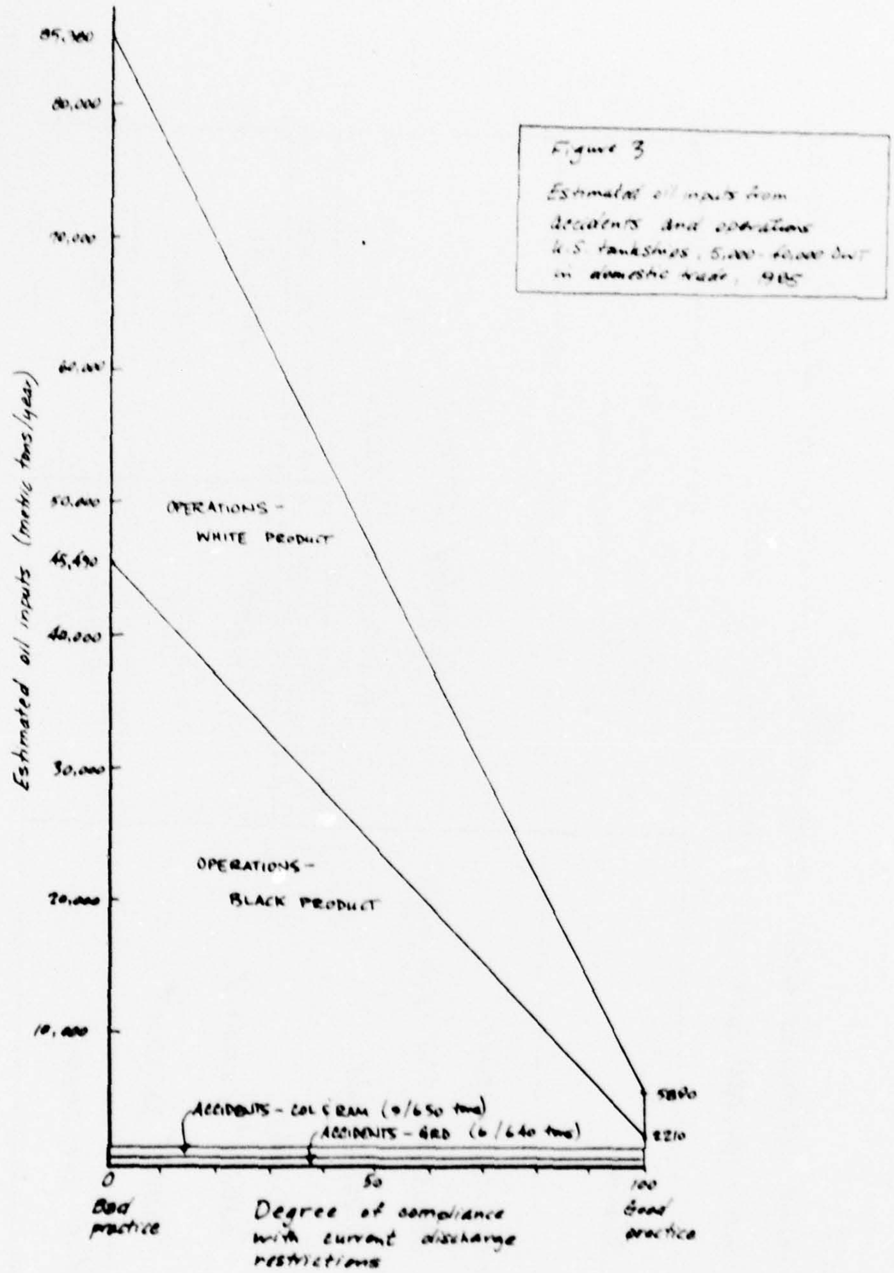


Figure 3
Estimated oil inputs from accidents and operations U.S. tankships, 5,000-60,000 DWT in domestic trade, 1985

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Calculations for estimate of oil inputs from operations of U.S. tankships in domestic trade, 5,000 DWT – 40,000 DWT, in 1985

1. Amount of oil moved in 1985

Estimated total 1985 product movements by tankships 5,000–40,000 DWT = $69 \times 10^6$ metric tons

Assume this is 80% "white" product, 20% "black" product (as was case in 1975). Amounts of each to be transported are:

$$\text{"white" product} = 0.8(69 \times 10^6) = 55.2 \times 10^6 \text{ metric tons}$$

$$\text{"black" product} = 0.2(69 \times 10^6) = 13.8 \times 10^6 \text{ metric tons}$$

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2. Oil input, "white" product, 5,000-40,000 dwt; 1985

Assume:

(1) $55.2 \times 10^6$ metric tons of "white" product transported

(2) cargo retained on board = 0.08% of cargo carried (Table 3, avg of 0.06% and 0.10%)

(3) 75% of tanks cleaned each trip to avoid contamination of next cargo

(4) In addition to (3) above, 20% of tanks ballasted prior to departure (dirty ballast)

(5) "good practice" implies good stripping and flushing of cargo lines so oil in cargo lines and "puddles" is retained on the vessel and vessel complies with discharge criteria (1/15,000 dwt discharge limit)

(6) "bad practice" implies no effort made to strip and flush cargo piping, oil in cargo piping and "puddles" discharged overboard

Then, for "bad practice"

oil discharged to sea (from ballast) $= (55.2 \times 10^6)(.0008)(.20) = 8830$ tons/yr

oil discharged to sea (from tank cleaning) $= (55.2 \times 10^6)(.0008)(.75) = 33,100$ tons/yr

total = 41,930 metric tons/year

and for "good practice"

oil discharged $= (55.2 \times 10^6) \times \frac{1}{15,000} = 3,680$ metric tons/year

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3. Oil imports, "black" product, 5,000–40,000 DWT, 1985

Assume: (1) $13.8 \times 10^6$ metric tons of "black" product transported by U.S. tankships, 5,000–40,000 DWT, in domestic trade.

(2) cargo retained on board = 0.4% of cargo carried

(3) 20% of tanks ballasted prior to departure (dirty ballast)

(4) 60% of tanks cleaned for sludge buildup and cargo purity reasons

(5) "good practice" implies compliance with discharge criteria (1/15,000 DWT) by use of good stripping and flushing practice, retention-on-board techniques, and reception facility.

(6) "bad practice" implies all oily mixtures discharged at sea, no special effort made to retain oily residues on board.

Then for "bad practice"

$$\text{oil to sea (from ballast)} = (13.8 \times 10^6)(.004)(.2) = 11{,}040 \text{ tons/yr}$$

$$\text{oil to sea (from tank cleaning)} = (13.8 \times 10^6)(.004)(.6) = \underline{33{,}120} \text{ ton/yr}$$

$$\text{total} = 44{,}160 \text{ ton/yr}$$

and "good practice", $\text{oil to sea} = 13.8 \times 10^6 \times \frac{1}{15{,}000} = 920 \text{ ton/yr}$

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ESTIMATE OF IMPACT OF MEASURES ON OIL OUTFLOW

The objective of this section is to provide a gross estimate of the possible impact various measures being considered on 1985 estimated oil outflows, using available data with approximations and uncertainties identified so their effects on the validity of the estimate can be evaluated at the end of the estimating process.

It is expected that the following measures would have a significant impact on oil inputs from U. S. tankers in domestic trade:

SBT on existing tankships would reduce operation oil inputs by eliminating ballasting of cargo tanks and tank cleaning to provide space for clean ballast as sources of operation oil inputs.

PL/SBT or DB on new tankships would, in addition to operational benefits of SBT, reduce accidental oil inputs from tankships by providing increased protection against oil outflow following grounding or collision.

The impact of SBT on operational oil inputs from product tankers would be limited to inputs from ballasting of dirty cargo tanks and tank clearing to provide space for clean ballast. SBT would not affect tank cleaning done for other reason, which on product carriers is the bulk of the tank cleaning done. The impact of SBT may be estimated as follows:

Calculations for estimate of impact of SBT and CBT on oil inputs from operations of U.S. tankships, 5,000 DWT - 40,000 DWT, in domestic trade in 1985.

1. "White" product

Introduction of SBT or CBT would not affect 75% of tanks assumed to be cleaned to avoid contamination of next cargo by residues of last cargo, but it would avoid oil input from dirty departure ballast. With other assumptions used before, "bad practice":

| | | |
|---|---|---|
| oil to sea (from ballast) | = | 0 |
| oil to sea (from tank cleaning) | = | 33,100 tons/year |
| total | | 33,100 tons/year |

SBT or CBT would make it easier to meet discharge criteria, but would not improve "good performance" estimates materially.

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2. "Black product"

SBT or CBT would affect oil input from dirty departure ballast, but would not affect 60% of tanks assumed to be cleaned to remove sludge buildup and to avoid cargo contamination. With other assumptions used before "good practice":

oil to sea (from ballast) = 0

oil to sea (from tank cleaning) =

$(13.8 \times 10^6)(.004)(.6) =$ 33,120 tons/year

total 33,120 tons/year

SBT or CBT would make it easier to meet discharge criteria but would not improve "good performance" estimates materially.

3. Total reduction in oil inputs due to SBT or CBT

| | |
|---|---|
| Saving - "white" product - ballasting | 6830 tons/year |
| Saving - "black" product - ballasting | 11,040 tons/year |
| Total reduction | 17,870 metric tons/year |
| | ≈ 18,000 metric tons/year |

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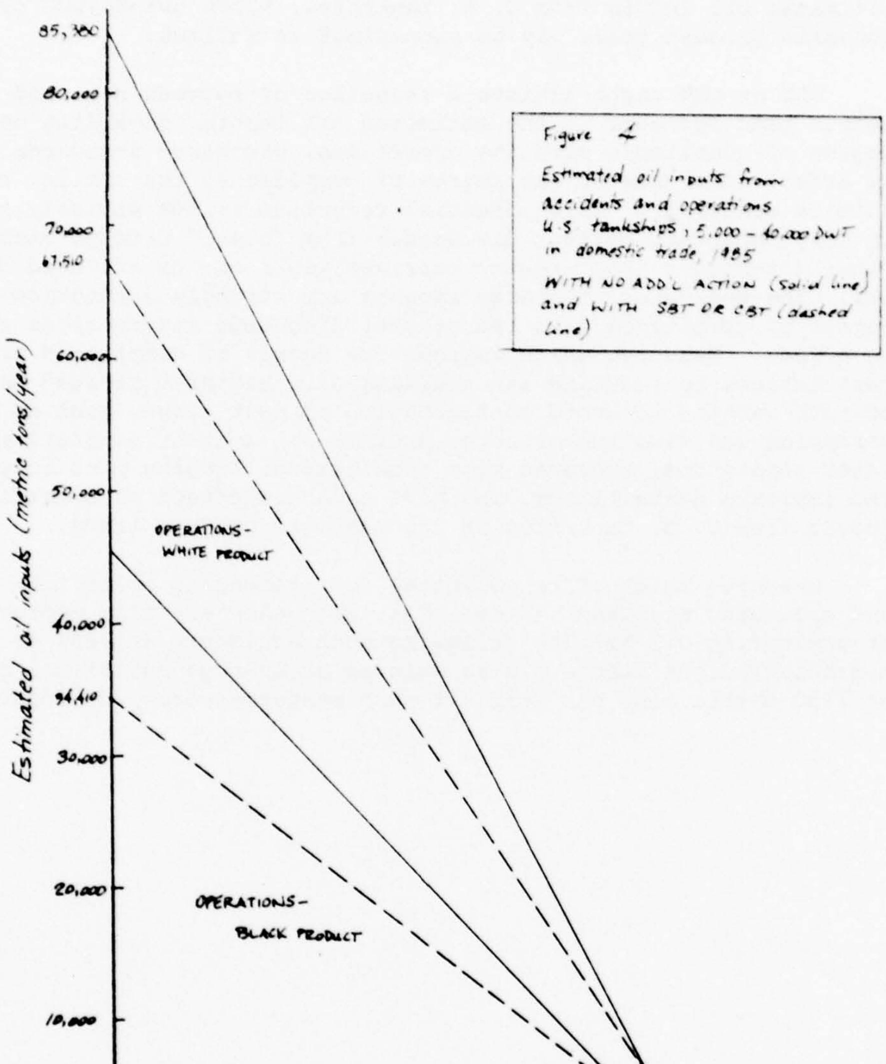


Figure 4

Estimated oil inputs from accidents and operations U.S tankships, 5,000 - 40,000 DWT in domestic trade, 1985

WITH NO ADD'L ACTION (Solid line) and WITH SBT OR CBT (dashed line)

SUMMARY OF IMPACT OF MEASURES ON OIL OUTFLOW

Under the above assumptions, the impact of SBT or CBT on 1985 estimated oil inputs from U. S. tankships, 5,000 dwt-40,000 dwt, in domestic product trade may be summarized as follows:

SBT or CBT might achieve a reduction of between zero and 11,000 metric tons per year in the estimated oil inputs, depending on the degree of compliance with the operational discharge standards already in effect (the greater the degree of compliance, the smaller the reduction achieved). This potential reduction is due entirely to reduction in oily departure ballast discharges from "black" product carriers. Other discharges from product carriers would not be affected by SBT or CBT. The estimated discharge amounts are strongly a function of the degree of compliance with operational discharge restrictions currently in effect. Measures which improve the degree of compliance with these restrictions in reducing and treating oily mixtures created as a result of tank washing to avoid contamination of next cargo, such as improved stripping and flushing or cargo piping, oil content monitors and oily-water separators, improved slop tank design, loading port inspection, and improved surveillance, can have a marked effect on operational oil inputs from U. S. tankships in the domestic product trade.

Measures which offer potential for preventing collision, ramming, and grounding accidents (Radar, CAA, emergency steering improvements) or preventing oil outflow following such accidents (PL/SBT or DB on new tankships) might also avoid as much as an average additional oil input of 1290 metric tons per year (if such measures were 100% effective).

## REFERENCES TO APPENDIX C


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2. H. D. Van Cleave, Henry P. Santiago, and Walter B. Chappel, Techniques for Controlling Oil Discharge from Product Oil Tankers," Paper SYMP VI/5 Symposium on Prevention of Pollution Ships, Acapulco, Mexico, 22-31 March 1976.

3. Department of Transportation, Coast Guard, Draft Environmental Impact Statement; International Conference on Tanker Safety and Pollution Prevention, Washington, D.C., February 1978.

APPENDIX-D

# ESTIMATING ECONOMIC AND ENVIRONMENTAL BENEFITS OF APPLYING MORE STRINGENT STRUCTURAL AND OPERATIONAL REQUIREMENTS TO U.S. TANKERS IN DOMESTIC TRADE

Office of Ocean Management
National Oceanic and Atmospheric Administration
U.S. DEPARTMENT OF COMMERCE
June 20, 1978

## CONTENTS

# I. INTRODUCTION

This paper analyzes potential economic and environmental benefits which may accrue from the application of additional provisions to the U.S. Jones Act Fleet over and above those envisioned by the Protocols of the 1978 International Conference on Tanker Safety and Pollution Prevention (TSPP).

Unfortunately, it is still not possible to estimate quantatively many of the benefits (damages avoided) which result from reduction in oil outflows to the marine environment. While economic theory is sufficiently developed to categorize these values and to measure the losses, the important linkages between the impact of oil on the environment and the resulting losses in value experienced by society have not yet been adequately established. Crucial ecological impact data and information about the values society places on many of the non-market (unpriced) goods, such as the value of a recreational beach day, and the change in these values resulting from oil pollution damages, must become available before comprehensive benefit estimates can be made.

It is important that a continuing effort be made to improve the current understanding of the complex linkages between oil pollution and economic damages. Without better benefit estimates there is a danger that inappropriate decisions will be made, particularly on those projects which involve significant costs to reduce marine oil pollution. The costs of control can be estimated much more readily than the benefits because in most cases cost calculations are based upon with well established market prices. Thus, in a simple comparison of the costs and the benefits of a particular

environmental protection decision, measureable costs will often far exceed measureable benefits. Inappropriate decisions can arise when the unmeasured benefits are highly valued by society and outweigh costs, but are not so evidenced in standard benefit/cost analyses.

In order to help reduce some of the uncertainty facing a decisionmaker considering the imposition of new pollution prevention measures on the Jones Act Fleet this paper:

(1) Discusses, in elementary terms, economic theory applied to the measurement of economic damages avoided (benefits) from oil pollution reduction from tank ships.

(2) Outlines an economic approach for measuring environmental damage from oil pollution if sufficient data available.

(3) Discusses, in quantative and qualitative terms, the severity of oil pollution damages arising from tanker spills and presents empirical estimates taken from previous studies that illustrate the types and the range of such damages.

(4) Estimates, where possible, actual economic benefits associated with reduced oil outflows from the Jones Act Fleet and compare these benefits with the costs of imposing the proposed new standards.

## II. ECONOMIC THEORY APPLIED TO VALUATION OF ENVIRONMENTAL BENEFITS

There are two economic concepts relevant to the evaluation of oil spill damages. One is consumers' surplus and the other is producers' surplus, or pure economic profit. Their sum gives the total economic value of a resource service called social surplus.

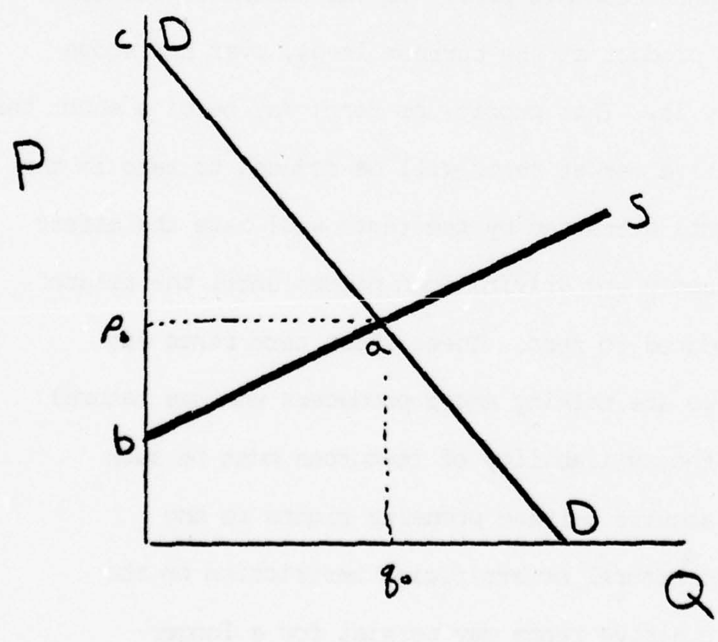
Consumer's surplus refers to the amount a consumer of a good or service would be willing to pay to maintain his consumption, of a good or service over and above what he actually has to pay. Aggregated overall consumers this gives the total value of goods or service to consumers, or consumers' surplus.

Producer's surplus or pure economic profit is the amount a producer receives for supplying his product at the current level, over and above what it costs him to supply it. This profit, or rent, may be of a short term or long term nature. In a competitive market rents will be reduced to zero in the long run because new entrants attracted by the rents will have the effect of increasing the market supply and driving down prices until the return over and above costs is reduced to zero. These short term rents are called quasi rents. When we are talking about producers who use natural resources, this must mean the availability of resources must be such that each new entrant can acquire private property rights to the resource. If there is some natural or artificial restriction on the expansion of output, then positive rents may persist for a longer period of time. For example, there may be a limited supply of a high quality natural resource, and this may be owned by existing producers. New entrants must purchase lower quality resources. Their costs are

higher and thus will not push price down to the level of the lower cost initial producers, who will maintain some positive rents. In the long run, this positive rent will be capitalized into the price of the higher quality land, because it is on account of its scarcity that the rent exists. Aggregating over all suppliers of a product gives producers' surplus.

The general approach to measuring consumers' surpluses and producers' rents empirically is illustrated by figure 1 below, where DD is the market demand curve representing willingness to pay for

Figure 1



various amounts of good Q and S is the market supply curve indicating the marginal cost of supplying each extra unit of Q. The market clearing price and quantity are $p_o$ and $Q_o$. The consumers' surplus is $cap_o$, and the producers' rent $p_ob$. The net value of producing $q_o$ units of Q is thus cab. If either the demand or supply curve were to shift, the total value (social surplus) would change changes in producers rent and consumers' surplus.

There are, however, some stipulations attached to this measure of value. Consumers' surplus can accurately be measured as the area under the demand curve only when certain conditions are me, or at least nearly met. Although these assumptions will not be discussed further here, they can affect the validity of certain empirical approaches to the measurement of value.

## III. MEASURING ECONOMIC IMPACTS OF OIL POLLUTION

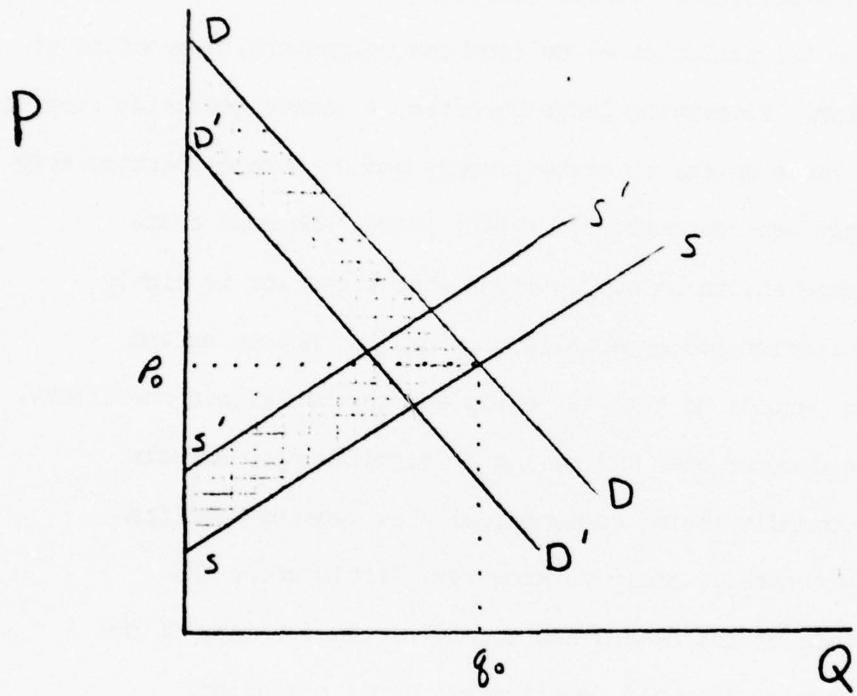
One can view the economic impact of oil pollution in two ways. In the first view, the cost of supplying a particular resource may rise, as when young fish are killed and subsequent fishing produces a lower catch per unit of effort. Similarly, the cost of supplying an aethetically pleasing recreational day on the beach rises if a beach has to be cleaned after being covered with oil. Viewing the damages from oil pollution as the costs which would be incurred to restore the resource to the state which prevailed before the polluting incident can overstate actual damages. Consumers may not view the loss in welfare were there are no restoration or only partial restoration as highly as the costs of restoration. When consumer losses do justify complete restoration (benefits from doing so at least equal costs), the damages are the costs of restoration plus the use value which is foregone while waiting for the cleanup.

The second view of pollution damages recognizes the quality dimension of many resources and measures damages from shifts in the demand which arise from quality changes.

Typically, it is appropriate to consider both shifts in supply and in demand arising from a single pollution incident. Consider, for example, the impact of oil pollution on a resource such as shellfish. The pollution may kill large numbers, creating increased costs of locating and harvesting the shellfish. At the same time the demand for those which are brought to market may shift downward if it is perceived that shellfish quality is diminished by the pollution.

The damages to a particular resource are the loses in social surplus. Figure 2 depicts a situation in which both supply and demand have been shifted.

Figure 2




Before the pollution incident demand D-D and supply S-S were in equilibrium at $p_o$, $q_o$. Oil pollution shifts demand downward to D'D' and supply upward to S'S'. The loss in social surplus equals the cross hatched area. Loss in social surplus can be divided into two aras, that resulting from the demand shift and that resulting from the demand shift and that resulting from the supply shift (this double counts the area where both shift). The component from the demand shift is larger the greater is the vertical shift in demand and the more responsive is demand to price changes (the more nearly horizontal is the demand curve).

The component of loss of social surplus resulting from the shift in supply is larger than greater is the shift in supply and the more responsible is supply to price changes.

These general considerations provide substantial insight into the probable economic damages from oil pollution -- or from the corresponding benefits of reducing oil pollution. To provide large benefits, a tanker pollution control devise must prevent large shifts in either supply and or demand, particularly when demand and supply are responsive to market price. Where do these conditions hold? Large shifts in supply occur when a species is highly vulnerable to oil pollution and especially so when the impacts extend over relatively long periods of time (an example might be certain shellfish). Large shifts in demand occur when oil pollution significantly affects the quality of the commodity being consumed, such as causing shellfish to be tainted. Unfortunately, analysts know very little about the responsiveness to price of the demand and supply curves for many of the goods whose quantity or quality may be affected by oil pollution. The state of knowledge regarding the impact of oil pollution on supply and demand is limited by two principal factors. The first link, from an oil pollution incident to changes in resource quantity and quality is poorly understood the second link, from resource quality or quantity to consumer demand, is also not well understood. Some research has been undertaken on both linkages and will be discused in a later section.

## IV. TYPES OF IMPACTS WHICH RESULT IN ECONOMIC LOSSES

Damages from tanker related oil spills can result in a broad spectrum of economic impacts. The purpose of this section is to discuss categories of impacts and to explain why it is important to translate them into economic values when estimating benefits associated with tanker pollution control measures.

Damages from tanker spills can be thought of in terms of the short run and the long run. Short term damages are usually the most dramatic and highly publicized. The following represents short term damage categories any one or all of which can occur as a result of a single tanker spill:

- Injuries and mortalities to commerical fish species resulting in loss of income to fishers and consumer surplus to fish eaters.
- Loss of recreational fishing days to recreational fishers.
- Fouling of fishing gear.
- Fouling of pleasure boats and damage to equipment.
- Fouling of aquaculture installations and damage to equipment.
- Fouling and damage to docks, seawalls and other personal property.

- Fouling of beaches and losses to recreational beach users from closed beaches.

- Losses to society (recreationists and permanent residents) from fouling of aesthetically pleasing coastlines resulting in unsightly visual impacts and unpleasant oders.

- Loss in existence and psychic values to human populations from injury and death to living marine organisms.

- Losses to the recreational tourism industry i.e., reduced hotel room rentals, decreases in retail establishment sales, etc.

- Partial or complete destruction of kelp and algae beds.

- Contamination of skin diving areas and damages to unique underwater geological structures.

- Losses in property values to owners of coastal real estate.

- Economic loss of the petroleum product to its owners.

- Economic loss of the ship and the loss of jobs to the crew.
- Costs of personal injury and mortality of the tanker crew.
- Costs of search and rescue.
- Clean-up costs including additional damage done to the environment from clean-up operations such as the use of dispersants.
- Human health impacts from ingestion of high concentrations of hydrocarbons.

Long term damages which could result in economic losses are more difficult to define. These damages, by the very nature of their possible long term implications, have considerable uncertainty associated with them. Indeed, there may be categories of damages which have not yet occurred to analysts and which will only be revealed by future research.

The following is at least a partial list of long term damage categories of potential concern:

- Reduced light penetration to the biota from opaque oil fractions and possible biological damages.
- Destruction or disruption of breeding habitat for marine organisms thereby reducing recruitment of young into biological populations.
- Disruption of the ecological balances of the marine biota in the area of the spill resulting in a change in the mix of specie diversity.
- Effects on biological productivity of continued build up of hydrocarbons in the oceans.

- Possible long term health effects of growing hydrocarbon concentrations in the oceans.

- Long term biological and human health effects associated with continued of dipersants and detergents during clean-up operations.

Many of the above categories of damages involve non-market goods. This fact makes their measurement extremely difficult. However, there has and continues to be important economic research undertaken to try and measure these costs, both theoretically and empirically. Examples of economic studies of actual spill damages undertaken to date include social costs associated with the 1976 ARGO MERCHANT tanker spill, the 1967 Torrey-Canyon tanker spill, the 1976 *Stewart Petroleum* barge spill in the Chesapeake Bay, and a forthcoming study of the AMOCO-CADIZ tanker accident. A brief explanation of the damages associated with these spills and how they were estimated will give the reader an idea of of the limitations of current research results and indicate areas where continued research would be appropriate.

- The ARGO-MERCHANT Oil Spill[1]

 The ARGO MERCHANT ran aground and eventually sank 27 miles offshore of Nantucket Island on December 15, 1976, spilling some 25,000 barrels of No. 6 industrial oil into the Atlantic Ocean.

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[1] Comptroller General of the United States, Total Costs Resulting From Two Major Oil Spills, United States General Accounting Office, June, 1977.

General Accounting Office (GAO) estimates of the costs of the spill include only a fraction of the above damage categories. Fortunately little if any of the spilled oil reached shore, eliminating the need for extensive cleanup and minimizing impacts to recreation, private property and near-shore fisheries.

Below is a list of the damage categories compiled by the GAO, with cost estimates:

| | |
|---|---|
| Salvage and Search & Rescue, U.S.C.G. | $1,885,000 |
| Scientific Research | 784,000 |
| Replacement Costs of Marine Birds[a] | |
| Last Cargo | 2,400,000 |
| Misc. (other Private, Federal, State and Local Agency Expenses, Administrative Costs, Bird Rehabilitation, etc.) | 200,000 |
| TOTAL | $5,200,000 |

[a] The GAO report estimates that 540 birds were killed by the oil and using a replacement cost of between $10 and $25 per bird, depending on the species, they arrived at the above estimate. The costs per bird were derived from estimates of their current purchase price at commercial bird hatcheries.

No estimates of value of the lost ship were made. Further, because the observable impacts to fisheries in the area were minimal, no estimates of commercial fisheries damages were made. Other damage categories were either not relevant in this incident or the impacts were unmeasured.

One area of current controversy is illustrated by the estimate given for replacement costs of marine birds. There have been opinions offered that after

a spill has occurred the public has the right to have the environment returned to the natural state it was in prior to the spill. While this argument has some compelling logic, there are counterveiling arguments which also have validity.

If society were to spend more money for rehabilitation of the natural environment than it is actually worth to them it would be an inefficient use of funds. For example, while it may cost $25 to replace a single duck lost in an oil spill, society may value that duck at something less than $25. The actual replacement cost of a seagull is somewhere in the area of $10 per bird. Yet, given their large numbers and undesirable qualities as far as some individuals are concerned, one must question whether the $10 spent to replace a seagull could not be better spent elsewhere, such as on reducing oil outflows from tanker accidents and operations.

Unfortunately, we really don't know the value society attaches to wildlife or other components of the natural environment. Until we do it will be impossible to know whether the benefits of rehabilitation area at least equal to or greater than the costs.

° The TORREY-CANYON Oil Spill[2]

On Saturday, March 18, 1967 the VLCC TORREY-CANYON ran aground 11 miles southwest of Sands End, England at a speed of 16 knots while enroute to Milford Haven, England with a cargo of 119,000 tons of Kuwait crude oil.

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2 Barrows, Paul, Rowley, Charles and Owen, David, "Torrey Canyon: A Case Study In Accidental Pollution," Scottish Journal of Political Economy, Vol. XXI, No. 3, Nov. 1974.

The costs of the spill were classified into two categories for analytical purposes and include: internal costs-hull of the ship, cargo loss and salvage costs; external costs-cleanup costs; legal costs, and environmental costs. The costs of cleanup, salvage, and litigation were easily obtained. However, a quantification of the environmental damages has never been performed for the same lack of good data that was mentioned earlier in this paper as being a persistant problem.

The research performed to date has indicated the following about the extent of environmental damages:

(1) Damage to Recreation —

The overwhelming impression of the local authority officials (both within and outside Cornwall) who responded to our inquiry was that tourism had not been affected materially in 1967 by the TORREY CANYON pollution and that trade effects had been negligible. This may well have been the case, given the timing of the clean-up operations, since 90 percent of tourists to Cornwall concentrate their visits between June and September (British Travel Association, 1965, and Ministry of Housing and Local Government, 1970) and the Cornish beaches were effectively cleansed by end-May. Such would not have been the case, however, if the TORREY CANYON had grounded off the Cornish coast during the peak holiday season.

(2) Damage to Fisheries —

There are unresolved technical problems, in establishing casual relationships between the extent of oil and detergent pollution of the sea and the number and type of fish populations, which render any quantitative

assessment of the marine life losses incurred as a consequence of the TORREY CANYON incident extremely difficult. It is possible, however, to classify the principal types of damage into three groups, namely (a) toxic effects on fish and shellfish (especially relevant in shallow coastal waters where dilution effects are less than in the open sea); (b) tainting of fish and shellfish both by oil and by detergent. (The taste both of fish and of shellfish is extremely sensitive to small quantities of pollutants, making them at worst unsaleable, at best the subject of sales resistance, as occurred especially in France, but also in Cornwall). (c) fouling of fishing gear, both by surface oil slicks and by sunken oil. (Once the catch is affected it has to be thrown away.)

A detailed study of the effects of TORREY CANYON pollution on the fishing industry was undertaken by the Ministry of Agriculture and Fisheries (1968) immediately following the incident. The Ministry's own scientists were able to find no evidence that oil and detergent pollution had led to the death of commercial fish species in any significant quantities and little evidence of tainting. Catches in the period immediately following the accident and the commencement of spraying operations were normal and throughout the season catches as a whole were at or were above average. The ministry concluded:

> "In the absence of any observations to the contrary from fishermen or scientists it would appear correct to conclude that there was no direct harm to the fisheries, or so little harm that it was undetectable."

Fears were expressed at the time of the accident for the local shellfish industry. Fortunately, however, the main oyster beds in the Fal, Helford and Porthcuel estuaries were not affected. The lobster season started in April but

although inshore catches were slightly below average in some areas, offshore were above average. Tainting of the flesh of lobsters was found to disappear after they had been kept in unpolluted sea water for a short time. There was no evidence that crawfish were harmed.

In general terms, therefore, there was very little damage to commercial fisheries or shell fisheries. Nevertheless, it is worth quoting the cautionary note incorporated by the Ministry of Agriculture into their report:

> "That damage to commercial fisheries was so small was primarily due to the special conditions prevailing at this season of the year off the Cornish coast. An accidental factor of importance was no doubt the volability of the solvent/emulsifier, which must have been reduced considerably when these materials were used on the open coastline with much wave action."

(3) Damage to Wildlife --

No satisfactory way has yet been found to evaluate the economic coast of wildlife losses consequential upon oil pollution in coastal waters. Nevertheless, it is esential to describe briefly the implications of the TORREY CANYON incident for wildlife other than marine life to complete the discussion on the costs of damage. The cost of wildlife losses may well have been substantial. For the oil released by the TORREY CANYON and the detergent applied to disperse it from the beaches caused widespread damage to intertidal marine plant and animal life, and were responsible for the destruction of significant numbers of sea birds over a wide area. Back shore dune and cliff plants suffered from bulldozing and trampling by decontamination workers

and from spillages of detergent. Since these forms of wildlife have virtually no commercial value and since many of the sea birds were of species such as guillemots, razorbills, puffins and divers which are rarely seen by birdwatchers since they remain for the mot part at sea (Bourne, 1968) it is extremely difficult to cost out the welfare losses involved. Nevertheless, some considerable cost there was, if only in the public suffering invoked by the graphic newspaper and television attention to the suffering of oil birds.

The number of birds destroyed by TORREY CANYON pollution can only be guessed at. Nearly 8,000 birds were handled at the Cornish cleaning centers and another 2,000 at the French centres in Brittany, nearly all of which died (Technical Sub-Committee, 1971). Thus the minimum loss must have been 10,000 birds but Bourne (1968) has suggested that the full total could have been up to ten times as large. The lack of any detailed information on the size of the bird populations makes any assessment of the long-term damage difficult especially as many of the birds were still immature and were not due to breed for several years.

Excepting the early massacre of seabirds, the oil which polluted the Cornish coast did far less damage to wildlife than did the detergent which was to clean the coastline (Smith, 1968). For detergent applications decimated crustacea, rockpool fish, worms, sea anemones, seaweeds and other littoral fauna and flora. Although there was little public concern over this aspect of environmental damage, the environmental damage may well have been much higher than for seabird losses in that the number, diversity and scarcity of the species involved was very much more important. There can be no doubt that major damage occurred to the ecology of parts of the Cornish coastline and that

the damage to plankton and larvae considerably delayed recolonisation of the denuded areas. Once again, however, there is no direct way of placing a cost estimate on the resources which were damaged and destroyed.

The preceeding discussion should help provide the reader with an understanding of the extent and magnitude of the environmental damages which can result from a near-shore, high outflow, oil spill; the type of damage we can expect will be reduced with more stringent requirements placed on the U.S. domestic tanker fleet. It should be noted, however, that a high percentage of the outflow prevented by stricter requirements would be of the nature of reduced operational outflows which are chronic and presumably less catastrophic in their immediate impacts than large scale accidents such as the TORREY CANYON spill. None-the-less, some of the new requirements recommended earlier in this report will reduce the probability of large accidental outflows or reduce future catastrophic environmental damages.

Below is a table which summarizes the estimates of damages (internal as well as external) made by Burrows, et al.

TABLE I

THE COST OF TORREY CANYON

(Millions of Dollars, U.S. in 1967 Prices) 2 = $1 U.S.

| | | |
|---|---|---|
| 1. Internal Cost | | |
| (a) The hull of TORREY CANYON | 2.945 | |
| (b) The cargo | .30 | |
| (c) The salvage operations | .025 | 3.27 |

| | | |
|---|---|---|
| 2. External Cost of Prevention and Control (U.K.) | | |
| (a) The cost of avoiding coastal pollution of which: | 1.0 | |
| (i) deliberate exploding of ship | .20 | |
| (ii) application of detegernet at sea | .60 | |
| (iii) use of booms etc. | .15 | |
| iv) M.O.D. general overheads | .05 | |
| (b) The cost of clean-up of which: | | 1.35 |
| (i) labour and support | .95 | |
| (ii) detergent | .325 | 2.35 |
| (iii) machinery and equipment | .075 | |
| 3. External Cost of Control (France) Minimum estimate based on compensation claim | | 1.5 |
| 4. External Cost of Damage Extensive damage--but unquantifable | | |
| Total Quantifiable Cost | | 7.12 |

As can be seen, costs of cleanup and salvage totalled approximately \$2.5 million in 1967. At historical inflation rates this cost would be over \$5 million in 1977 dollars. These costs appear low when compared to the ARGO-MERCHANT spill cleanup and salvage costs given the fact that much more extensive cleanup and salvage operations were carried as a result of the TORREY CANYON spill than for the ARGO-MERCHANT.

° Stewart Petroleum Barge Spill [3, 4]

The STC-101 barge, alledgedly owned by the Stewart Petroleum Company sank about 4 miles offshore in Chesapeake Bay near the mouth of the Potomac River on February 2, 1976 spilling some 250,000 gallons of petroleum product.

The following table summarizes the GAO report estimates of the costs of the spill:

| Costs incurred by: | Amount |
|---|---|
| Coast Guard | $ 490,959 |
| Other Federal Agencies | 18,916 |
| State agencies | 36,465 |
| Local government | 7,071 |
| Private organizations | 10,409 |
| Cleanup costs incurred by spiller | 39,916 |
| Individual damage claims | 4,804 |
| | 608,540 |
| Estimated value of waterfowl killed by oil | 635,325 |
| | 1,243,865 |
| Estimated value of oil spilled | 78,750 |
| Total | a/ $1,322,615 |

3/ Brown, Gardner, M. JR. and Hannock, Judd, Economic Valuation of Waterfowl, entered as evidence in Commonwealth vs. Stewart, May, 1977.

4/ Comptroller General of the United States, LOC. CIT.

The value of the waterfowl killed in the spill was an estimate made by the Commonwealth of Virginia based on a combination of the fair market value and the replacement costs of the birds killed by oil. The number and species of the waterfowl were based on a count of the dead birds factored to compensate for birds which were killed but could not be counted (i.e., birds that did not wash ashore, birds eaten by predators, and birds that washed or crawled into inaccessible areas).

The estimated costs incurred by the Coast Guard and others totaled $608,540 and were for (1) cleanup and disposal of the oil—$524,229; (2) surveillance of the spill--$30,741; (3) evaluation of the impact of the spill on the environment—$18,978; (4) waterfowl rehabilitation, bird cleanup, and counting birds killed by the oil--$29,388; and (5) laboratory tests and damage claims—$5,204.

A study by the University of Georgia and Louisiana State University estimated the societal value of coastal wetlands in general at $50,000 to $80,000 per acre. However, the full extent of environmental impact on the wetlands of the Chesapeake Bay shore contaminated by oil is unknown. A possibilty exists that damage has been done to smaller life forms and oyster and oyster populations. The long-term effect on bird and fish populations will not be known for several years. The Fish and Wildlife Service, Department of the Interior, and the Virginia Institute of Marine Sciences did not believe any loss of fish or damage to the fisheries in the Bay occurred because of the spill.

Costs of $401,191 for containment and cleanup have been reimbursed from the pollution fund as a result of this spill. Appendix IV provides details of the amounts and the agencies which received reimbursement.

During GAO's review no recovery had been made of costs incurred as a result of this spill; Stewart Transportation has denied any responsibility. The Department of Justice has filed a lawsuit against Stewart Transportation to recover about $487,000 for costs incurred in the Federal cleanup operations and $1 million for loss of waterfowl. In addition, the Commonwealth of Virginia has a suit pending against Stewart Transportation for $731,500 which includes the estimated value of the waterfowl killed by the oil spill. The merits of these cases have not yet been determined to our knowledge.

The estimates of wildfowl losses appearing above again involve the controversial "replacement cost" approach. In to better estimate the true social cost of this loss, the State of Virginia hired two economic consultants to make an independent evaluation. Using a well formulated and tested methodology Brown and Hammoch have estimated the true losses from damaged wildlife to be approximately $600,000, or very close to the replacement cost estimate in the GAO report. In this case both estimates are quite similar. However, the reader is cautioned not to assume that in all cases replacement costs can serve as an adequate surrogate for the social cost of wildlife damages.

Other non-quantifiable damages from the spill are discussed as follows:

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| Environmental entity | How affected |
| --- | --- |
| Oyster beds | An extensive population of oysters exists in the affected area, and many were heavily oiled. A significant mortality rate was noted in the oiled marsh areas in May 1976. The exact cause of death has not been determined. |
| Snails | A study of affected and unaffected areas showed that the snail population of marshes was adversely affected by cleanup operations. The snail population was decimated due to physical removal with oil-soaked grass; about four-fifths of the snails were removed. Almost normal populations were reestablished during the first year after the spill. |
| Saltmarsh cordgrass | The oil coated the marshes while they were relatively dormant. Thus, the initial impact was caused by cutting and removing the grass. Grass in the marsh areas where oil was cleaned up grew back with more stems, which uniformly grew to a shorter mean height and produced more seed heads. The result was an increase in net productivity. |
| Waterfowl | The Commonwealth of Virginia estimated that 30,936 birds wer killed by the oil spill. The long- erm effect on the breeding of various species is not known at this time. |

° AMOCO-CADIZ Spill[5]

At approximately 11:30 p.m. on Thursday, March 16, 1978, the supertanker AMOCO CADIZ went aground on rock outcropping 1.5 km offshore of Portsall on the northwest coast of France. The vessel contained a cargo of 216,000 tons of crude oil and 4,000 tons of bunker fuel. At 6:00 a.m. on Friday, March 17, the vessel broke just forward of the wheelhouse and thus started the worst oil spill in maritime history. During the course of the next 15 days, the bunker fuel and all 13 loaded cargo tanks, which contained two varieties of light mideastern crude oil, were relesed into the ocean. The oil quickly became a water-in-oil emulsion (mousse) of at least 50% water and heavily impacted nearly 140 km of the Brittany coast from Portsall to Ile de Brehat. At one time or another oil contamination was observed along 393 km of coastline and at least 60 km offshore. Impacted areas included recreational beaches, mariculture impoundments and a substantial marine fishery industry.

Since the ARGO MERCHANT oil spill in December 1976, EPA and NOAA have collaborated in development of an interagency oil spill response team, encompassing a variety of scientific disciplines. In the U.S. this team has three functions:

(1) To provide authorities responible for cleanup with highly-qualified scientific assistance in mitigating the environment and socio-enconomic impacts of spills of oil and other hazardous substances.

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5 U.S. Ddept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, The AMOCO-CADIZ Oil Spill - A Preliminary Scientific Report, April, 1978.

(2) To provide scientific assistance in assessing the damage resulting from such spills.

(3) To maximize the research advantage offered by the spill situation, especially with respect to improving future response capabilities.

NOAA team members initially arrived on-scene on Sunday, March 19. Initial photographic over-flights and active beach sampling began on Tuesday, March 21, followed by initial chemical sampling by vessel on Friday, March 24. The team was supplemented with EPA biological observers on Sunday, March 26. Routine sampling has continued by all segments of the team until the present time.

Throughout the period of investigation, active interaction and coordination with the French scientific community has taken place under the auspices of COB/CNEXO. All sampling has been coordinated with programs organized by CNEXO and other institutions in France, enabling a more thorough evaluation of the effects of the incident than would have otherwise been possible.

During the course of the investigation, 8 observational objectives were established by the U.S. team:

1. Photographic mapping of impacted beaches from overflights.
2. Statistical mapping of the distribution of oil on the water surface using vertical photography.
3. Surveys of impacted beaches over complete tidal cycles.
4. Surveys of the concentrations of oil in subsurface water.

5. Evaluation of the effect of weathering on the composition of surface oil as a function of time/distance from the wreck site

6. Evaluation of the long-term effects of weathering on the composition of oil in sediments from tidal flats and beaches.

7. Evaluation of the biological consequences of the spill.

8. Observation and assessment of cleanup technique.

Given the limitations of our analytical efforts to date, we believe the following preliminary conclusions can be drawn regarding the nature, fate and effects of the oil spilled from the Amoco Cadiz:

1. According to our best estimate, 64,000 tons of the Amoco Cadiz oil came ashore along 72 km of the shoreline of Brittany during the first few weeks of the spill. A prevailing westerly wind pushed the oil against west-facing headlands and into shoreline embayments as it moved east. Additional wind-induced forcing is hypothesized to have taken place through a sea surface set-up along the coast and subsequent development of a significant alongshore current. A wind reversal in early April moved the oil in the opposite direction, contaminating previously untouched areas and transporting the oil as far southwest as Pointe du Raz (southwest of Brest). At the end of April, the total volume of oil onshore was reduced to 11,000 tons, but, by that time, 393 km of shoreline had been contaminated.

2. Coastal processes and geomorphology played a major role in the dispersal and accumulation of the oil once it came onshore. For example, oil accumulated at the heads of crenulate bays and on tombolos (sand

spits formed in the lee of offshore islands). Local sinks, such as scour pits around boulders, bar troughs (runnels), marsh pools, and joints and crevasses in rocks, tended to trap oil. The grounded mousse was either eroded away, or buried (up to 70 cm) under new sediment deposits, in response to the vagaries of the beach cycle.

3. During the initial oiling, the first week after the grounding, oil definitely lifted off with the incoming tide, and was redeposited on the ebb. However, by late April oil/sediment binding was pronounced and considerable sinking was evident. A significant percentage of the oil spilled by the Amoco Cadiz is now hypothesized to have actually sunk to the bottom and thereafter been subjected to bottom transport processes.

4. The distribution of oil in water in the Abers Wrach estuary was uniform vertically indicating the benthos were exposed to oil. Six weeks after the grounding, this estuary still contained elevated concentrations of oil in water, particularly at the upper end.

5. Offshore, high concentrations of oil in water were observed under patches of mousse or slick, but, interestingly, near bottom water usually contained even greater quantities of oil.

6. Adverse biological effects of the spill were observed along the northwest coast of Brittany ranging from Portsall to Perros-Guirec - a distance of about 150 km of coastline plus numerous rocky outcroppings and islands. Biological communities in these habitats were stressed to varying degrees depending upon type of habitat, distance from the spill and location relative to the configuration of the coastline.

7. Intertidal communities on coastlines facing in a westerly direction, as well as the Aber-Benoit estuary and Rulosquet marsh near Ile Grande were severely impacted. These effects were maximized by spring tides which occurred just after the wreck. Massive mortalities of intertidal communities occurred near St. Efflam and at Rulosquet marsh over a relatively short time span (a few days) while mortalities of other populations were observed to occur more gradually (over several weeks). Populations of intertidal crabs, nereid worms, bivalve molluscs and limpets were much more acutely effected by the spill than were deposit-feeders (e.g. Arenicola). For epifauna, mortality appeared related to physical coating by the oil while the dissolved fraction which penetrated into the interstitial water was probably the primary factor contributing to mortalities of infauna. Acute effects were not observed on attached macroalgae although some evidence was obtained in an independent study that indicates that the fertilization process of exposed plants may be impaired, and that growth of Laminaria may be retarded.

8. The oil spill occurred at a time when many species of marine birds were in the process of migration from wintering to nesting

grounds. Over 3,200 deaths were recorded which consisted of more than 30 species. About 85% of these deaths, however, consisted of four species (shag cormoran, guillemont, razorbill and puffin); the latter three of which are considered as rare or threatened in France. More chronic impacts on marine birds may occur from feeding on contaminated prey. Seagulls were observed feeding on freshly killed intertidal organisms all along the impacted coastline.

9 . Mariculture operations for oysters were severely affected in the Aber Benoit and Aber Wrach estuaries and the Bay of Morlaix. Large numbers of oysters were either killed or contaminated by the spill. The holding pens of the commercial lobster operation at Roscoff were heavily oiled and probably will be out of operation for a year. The main scallop fishery in Brittany is located east of the impacted area and adverse effects may be minimal.

10 . The transport of oil or its volatile fractions to terrestrial communities may have been substantial. In late March gale force winds and spring tides combined to deposit oil above the high tide mark. More importantly, some of the airborne fractions of the petroleum can adhere to plants and be transported to man via farm crops or livestock.

11. The data collected at the Amoco Cadiz spill have given new insights into oil movement in the marine environment. These will prove useful in the development of conceptual algorithms to describe fundamental processes such as the stranding or beaching of oil,

sheltering of areas in the lee of headlands, roll of alongshore drift in oil transport and the effects of tidal pumping. These new conceptual understandings can be expected to contribute to the next generation of oil spill forecasting models and hydrocarbon impact assessment studies.

NOAA has also asked permission from the French Government to perform a comprehensive economic damage assessment of the effects of the spill. As yet, no official response has been given.

The spectrum of damages in keeping with the magnitude of oil spilled is extremely broad. The following sectors of the French economy have been damaged but as yet no estimates have been published.

Fisheries - little if any fishing is taking place in the impact zone at present.

Aquaculture - A major industry which has been all but closed in the spill region, perhaps continuing for many more months.

Kelp Algae - A very important cash crop to west Brittany and the entire French economy. Will be closed for many months.

Recreation/Tourism - Another very important industry and avocation of the French Citizenery. Beaches and near-shore waters are still oiled, thereby reducing tourist trade and the value of a recreational in the spill region.

Wildlife - Severely impacted perhaps for several years.

Cleanup Costs - Very high. Up to $1/3 million per day for over a 2 months have been spent so far. Cleanup and salvage costs could reach $40-50 million.

Human Health -- Possible adverse effects on human health from breathing high concentrations of hydrocarbons by cleanup crews and local residents. Also, because many local residents depend on fish in their diet; some have reportedly been consuming locally caught fish and shellfish which are heavily tainted withhydrocarbons.

Administrative/Litigation Costs - Unknown as present.

Property Values - A reduction in the value of shorefront property can be expected as its perceived aesthetic value is reduced to prospective buyers. It can not be estimated at present.

APPENDIX E

# METHODOLOGY FOR CALCULATING IMPACT ON TANKER AND OIL TRANSPORTATION COSTS

## Introduction

After review of expected reductions in demand through 1985, and the impact of regulatory alternatives, there appears to be a very large number of almost equally likely scenarios. As an alternative to making highly subjective evaluations about possible dynamic changes in the tanker fleet between now and 1985, the static optimal condition of the fleet in 1985 was first determined on the basis of a market demand and supply equilibrium analysis. The criterion of optimality in the market analysis is the lowest total cost. Even if there are institutional or other noneconomic reasons why the optimal fleet will not actually occur, it still has validity for assessing the benefits and costs of regulatory alternatives.

The rigorous nature of the market analysis focuses the uncertainty about the future onto explicitly defined narrow questions. Variables and relationships must be identified and specific values assigned to parameters. Opinions seem to converge about these questions rather than to diverge as they do in the scenario building approach. If a general review yields new information, the conclusions can be adjusted accordingly, rather than abandoned.

## Demand Analysis

Demand for transportation may be considered as a functional relationship between its price (freight rate) and the quantity of this service which users are willing to buy. The quantity desired of a good or service generally decreases as its price increases. Demand for a type of transportation is derived from the demand for the commodity carried and the availability and prices of alternative means for transporting the commodity. Demand for the commodity carried also depends on the availability and relative prices of substitute commodities. All of these conditions will vary over time, and the demand function for a transportation service at any time may be described in terms of price and quantity, given a set of conditions existing at that time. This representation, called a short run demand function, remains valid for as long as the parameters remain unchanged. When the conditions change, there will be a new short run demand function, and we say that demand has shifted.

The demands for the tonnage of small tank ships for crude oil and for petroleum products under alternative regulatory requirements are the concern in this study. Except for certain regulatory alternatives, tank ships may be interchangable between the two commodities. The number of small tank ships which would be dedicated only to the carriage of crude oil is so small that the effect will be negligible if the demands are combined for crude oil and petroleum products carriage in the domestic trade.

Although some of the tank ships which engage primarily in the domestic trade do occasionally engage in foreign trade, there is no identifiable amount of cargo which must be carried in these ships. Therefore, foreign trade is not included in the estimate of the demand for domestic small tank ships.

Since there is no reliable information that the demand for domestic oil will change, it is assumed to remain constant. Any growth in total oil demand will probably be met with increased imports of refined petroleum products which will not affect the demand for small domestic tankers. Should new regulations result in a significant increase in the price of domestic oil relative to foreign oil, there could be a substitution of the less expensive oil resulting in a reduction (shift) in the demand for domestic oil transportation. If the analysis does not take into account any such change in a parameter, then it will overestimate the demand by some amount.

The other conditions or parameters, involve the availability and relative prices of alternative means of transportation. Two transportation alternatives have been taken into account in the forecast of demand for 1985. A reduction in demand for small tankers is likely to occur resulting from construction of crude oil pipelines from the West Coast to the Midwest and expansion of products pipeline capacity from the Gulf coast to the Mid-Atlantic areas.

Other possible developments include other pipeline construction or expansion, the expanded use of barges in ocean oil transportation, and the increased use of overland transportation modes. The availability of such alternatives within a short time (less than 2-3 years) is severely limited. Therefore the short run demand schedule would not reflect the usual reduction in the quantity desired as freight rates increase. The virtual absence of short run substitutes means that we may describe short run demand for small domestic tankers as a quantity (tonnage) rather than a schedule of quantity versus price. In terms of economic analysis, we say that short run demand is almost perfectly inelastic; elasticity, a ratio of percent change in quantity to percent change in price, is virtually zero. Graphically, short run demand is a vertical line on a chart showing price versus quantity.

Calculations of estimates for short run demand in 1985, must establish the current level of demand and apply predictable adjustments for a forecast. However, voyage and cargo data needed for direct measurement are not readily available. Fairly recent data were available on total domestic oil movements by selfpropelled vessels of all sizes and identified by interregional or intraregional origins and destinations. It is feasible to infer from these data the demand for small domestic tankers, but the set of assumptions required for the inferrence become very tenuous. The method chosen was to take the existing fleet and deduct the equivalent tonnage currently employed in trades other than domestic oil carriage. The deductible tonnage is easily identified. Similarly, the tonnage currently used, where predictions are made for an expected reduction due to piepline development, is readily identifiable. As a cross check, the results of the two methods of identifying demand may be compared to see what kind of assumptions are needed in the more theoretical method for its results to agree with the more empirical method.

It is also recognized that the demand for domestic oil carriage is highly seasonal. The fleet is assumed to adjust to peak season demand levels and that off season excess capacity will be employed in other trades. There is some practical basis for such an assumption since some alternative employments are somewhat countercyclical (grain exports) or discretionary (Strategic Petroleum Reserve). Seasonality is considered further in the analysis of supply.

The 1985 domestic demand is forecasted to be 2.2 m DWT as shown in Section 2.1.2 The Demand for Tanker Transportation Services.

Supply Analysis

The supply of a transportation service may be described as a functional relationship between its price (freight rate) and the quantity which owners would offer in service. The quantity which owners would be willing to offer generally increases as price increases. The concept of a supply function represents differences among owners, for a variety of reasons, in levels of their costs of providing the service. The costs considered are economic costs which differ from accounting costs, especially as the latter are affected by tax regulations. The quantity offered is greater at higher price levels because the higher cost owners are able to participate in the market.

When a short run supply function is considered for tankers, it is not implied that the quantity (tonnage) offered can be adjusted and re-adjusted over the entire range within a short time. The short run supply function describes the relationship between freight rates and the total tonnage which, at any given time, could fully recover its economic costs at each rate level. Economic costs are identified for each tank ship and, starting with the lowest cost units, the total tonnage of the ships which can operate at progressively higher rate levels are determined. At any given rate level the total tonnage supply includes an identifiable fleet.

An examination of available information on total costs, including normal returns to capital investment, revealed that the costs varied in a fairly systematic way on the basis of age, size, and long term employment prospects. Rather than calculate a hypothetical required freight rate (RFR) for each ship, the calculation was simplified by dividing the existing fleet into groups which had similar values for the variables which affect costs. Then RFR may be calculated for a representative ship of each group with only a small variance from the RFR of individual ships in the group.

A short run supply function was calculated for a base case of the existing fleet with no additional pollution prevention regulations. Then similar supply functions were calculated accounting for the RFR to cover costs which include the costs imposed by the major regulatory alternatives under consideration. Since each ship's costs increase as its capacity is reduced, the RFR for any given total fleet tonnage is higher than the base case. Note carefully that the position of individual ships in order of increasing RFR also changes. The three variables which account for

differences in costs also account for differential cost impacts of regulatory requirements. In addition to calculating RFR for existing ships, we also found an RFR for a hypothetical new ship under each regulatory alternative. In any case where RFR for existing ships should exceed that for a new ship, the logical conclusion would be replacement by new construction.

The seasonality of product carrier demand forces one to examine carefully how cost recovery freight rates are treated in the construction of supply schedules. Unless cost recovery rates are available in other trades during the domestic product off season, ships may require higher than cost recovery rates during the peak season to sustain continued operation.

On the other hand, the tonnage supplied at any given rate includes all the ships whose cost recovery rate is lower than that given rate, and most of them could sustain operation during the off-season. Therefore, for any given rate, ignoring seasonality may result in over estimating to some extent, the tonnage that would be offered. In that case, the tonnage would be overstated at every point on the supply price schedule, so the equilibrium rate would be underestimated by some, probably slight, amount. Seasonality may be ignored for simplicity realizing that the actual required freight rate at market equillibrium may be slightly higher than our estimated value.

Graphic curves are presented for conceptual understanding with a caution about their use as a substitute for computation.

Market Equilibrium

Intersection of the demand and supply schedules shows the required fleet tonnage and prevailing freight rates after regulatory requirements have been satisfied and market adjustments have taken place. Because of the highly inelastic short run demand, tonnage may be determined by demand forecast, while rates reflect supply cost. Existing tonnage in excess of the equilibrium quantity would be redundant. It would not be modified to satisfy regulatory requirements for the trade, and would either find employment in other trades or be scrapped.

Application of the supply function model is used to identify each equilibrium solution, the groups of existing ships which may be modified and employed, and to calculate costs of modifications and loss of cargo capacity. If any replacement construction is indicated, the amount and cost may be calculated.

The differences in required freight rates at equilibrium are indicative of the economic cost of the regulatory alternatives. Total cost can be calculated from total deadweight tons and RFR.

## Categorization of Fleet

Rather than calculate RFRs for each ship, the fleet was separated into 36 categories and an RFR was derived from a representative "average" ship in each category.

Figure 1E schematically illustrates how the fleet was categorized on the basis of size, age, operation and whether or not the ship was rebuilt. Classification on the basis of size corresponds to readily observable groups of ships in certain deadweight tonnage ranges: 5,000-19,999 DWT; 20,000-23,999 DWT; 24,000-29,999 DWT; 30,000-34,999 DWT; and 35,000-39,999 DWT. Finally, ships in these categories were separated by age in 1985. For ships not rebuilt, the age categories are: 35 years or older; 30 to 34 years; 25 to 29 years; and less than 25 years. The age categories for rebuilt ships are: 20 years or older; 15 to 19 years; and less than 15 years.

Thirty-six groups resulted from this process, each containing ships which are very similar in those dimensions which have a large influence on the cost of ship operation. A list of the tankers used in the analysis is attached as Appendix F.

## RFR and Capital Cost Calculations

Required freight rates (RFR's) were calculated for an average ship in each of the existing fleet vessel categories that were defined and also for a new 30,000 DWT vessel. All costs have been calculated in U. S. dollars at the current 1978 levels of exchange.

Table 1E presents a typical worksheet. An average voyage length, 2720 miles, for the U. S. fleet in Jones Act oil trade was calculated based on movements in 1975. This average voyage length was used for all of the vessels in the size category 5,000 to 40,000 DWT. Actual voyage roundtrip distances ranged from 460 to 13,118 miles with the majority of the oil, however, moved on voyages of from 2,000 to 5,000 miles.

An adjustment in average vessel speed on the voyage was also made to account for CBT and SBT tankers operating lighter in both the loaded and ballasted conditions. Existing tankers were assumed to operate ballasted at about 50 percent of full displacement on the average. Their ballasted speed after SBT retrofit was assumed to increase by 4 percent with average operation at 40 percent of full displacement using Reference 1. An 0.8 percent increase in speed for the loaded condition is also assumed based on this reference and the DWT reductions. The overall increase in the CBT/SBT tanker speed over the entire voyage is then 0.4 knots. This speed increase was applied to all the CBT/SBT tankers.

The RFR for the new vessel of 30,000 DWT was calculated to be $9.481 ton.

FIGURE 1E

FLEET CATEGORIZATION

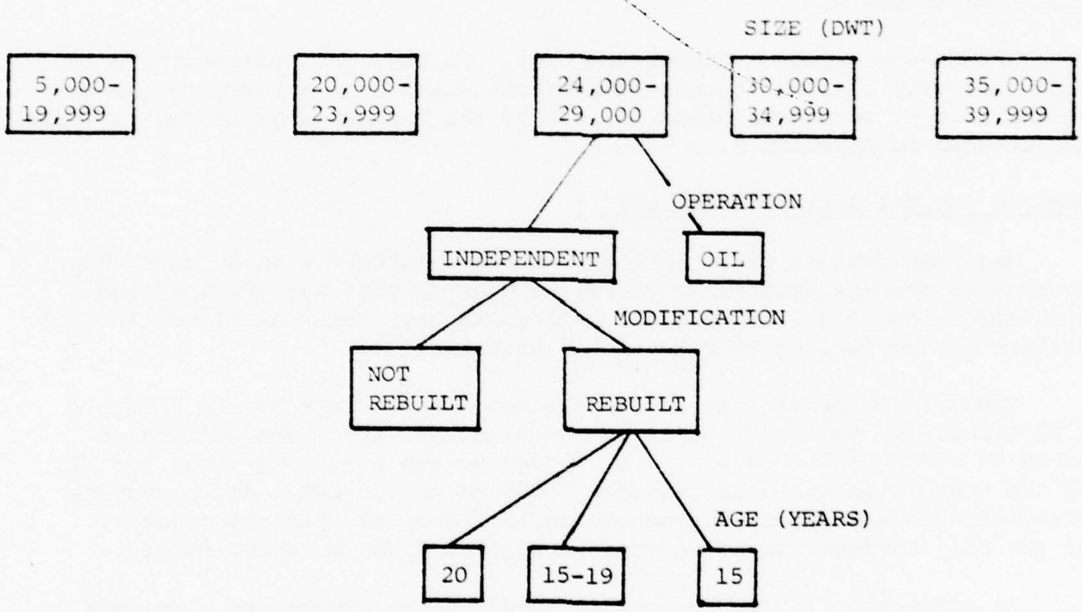

TABLE 1E

RFR CALCULATION WORKSHEET

| | | | | | | |
|---|---|---|---|---|---|---|
| Vessel | BASE | ALT 1 | ALT 2 | ALT 3 | ALT 4 | ALT 5 |
| Tanker DWT | 16,600 | 16,600 | 16,600 | 16,600 | 16,600 | 16,600 |
| Speed (Kts) | 16.0 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 |
| BBL/Day - At Sea | 310 | 310 | 310 | 310 | 310 | 310 |
| - In Port | 70 | 70 | 70 | 70 | 70 | 70 |
| Roundtrip (n.m.) | 2720 | 2720 | 2720 | 2720 | 2720 | 2720 |
| Sea Days | 7.08 | 6.91 | 6.91 | 6.91 | 6.91 | 6.91 |
| Port Days | 3 | 3 | 3 | 3 | 3 | 3 |
| Days/Trip | 10.08 | 9.91 | 9.91 | 9.91 | 9.91 | 9.91 |
| Operating Days/yr. | 350 | 350 | 350 | 350 | 350 | 350 |
| Trips/Yr. | 34.72 | 35.32 | 35.32 | 35.32 | 35.32 | 35.32 |
| % Effective Lost DWT | 0 | 27 | 27 | 27 | 27 | 27 |
| CDWT (Lt.) | 15694 | 11391 | 11391 | 15,604 | 11391 | 11391 |
| Cargo Del./Yr. (Lt/Yr) | 541.6 | 402.3 | 402.3 | 541.6 | 402.3 | 402.3 |
| 1977 Costs (x1000) | | | | | | |
| Operating Costs/Yr. | | | | | | |
| Wages | 1451 | 1481 | 1481 | 1451 | 1481 | 1451 |
| Subsistence | 52 | 52 | 52 | 52 | 52 | 52 |
| SS&E | 80 | 80 | 80 | 80 | 80 | 80 |
| M&R | 320 | 320 | 320 | 320 | 320 | 320 |
| Insurance | 132 | 132 | 132 | 132 | 132 | 132 |
| Other | 33 | 33 | 33 | 33 | 33 | 33 |
| Port Charges | 474 | 400 | 400 | 474 | 400 | 400 |
| Fuel ($11.50/BBL) | 960 | 955 | 955 | 960 | 955 | 955 |
| Total $/Year | 3502 | 3453 | 3453 | 3502 | 3453 | 3453 |
| Capital Costs | | | | | | |
| Avg. Delivery Yr. | | | | | | |
| Construction Cost | — | — | — | — | — | — |
| Retrofit Cost | — | 1400 | 1050 | — | 550 | 200 |
| Amortization | | | | | | |
| Construction CFR (20 yrs., 10%) | — | — | — | — | — | — |
| Retrofit CFR (1 year, 10%) | — | 1540 | 1160 | — | 605 | 221 |
| Total Yearly Costs | 3502 | 4993 | 4613 | 3502 | 4058 | 3674 |
| RFR ($/LT) | 6.47 | 12.41 | 11.47 | 6.47 | 10.09 | 9.13 |

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Required freight rates (RFRs) are calcaulated for a base case and five alternative regulatory cases as shown on Table 2E.

ALT1 - TSPP requirement extension down to 5,000 dwt and requiring SBT retrofit.

ALT2 - Same as ALT1 except that CBT is allowed.

ALT3 - Presidential initiative requirements extended down to 20,000 dwt with SBT retrofit.

ALT4 - Same as ALT1 but without IGS retrofit.

ALT5 - Same as ALT2 but without·IGS retrofit.

Each of the alternatives involves a loss in effective vessel carrying dwt capacity which significantly affects the RFR.

The new replacement 30,000 dwt tankers are assumed to be required to meet TSPP requirements to the lower DWT limits of the alternatives. The replacement vessel for the ALT3 scenario utilizes a double bottom approach.

Daily vessel operating expenses are based on numbers from a range of typical tankers in Reference 2. (Estimated Operating Expenses 1977, published by MarAd.)

The following formulas were developed from the reference for tankers in the 10,000 to 40,000 dwt range only. The formulas are generally inapplicable for the development of vessel operating expenses outside of this particular application.

Wages

Older tankers have larger crews than modern vessels but wages per man are higher on the newer ones because of the skills required to handle the increased sophistication of equipment. There is also an increase in vessel wage costs with ship size due to use of wage formulas that are a function of tonnage. The following formulation ignores specific variation with ship size but relates total wage cost for the tankers in reference to crew size. Tankers with large crews thus are implicitly assumed to be smaller and older.

$$\text{Wages } \frac{(\$)}{\text{Day}} = 1{,}602 + 90.94 \text{ (No. Crew)}$$

Subsistence

These costs are assumed to vary directly with crew size.

$$\text{Subsistence} = \frac{\$5.24}{\text{ManDay}}$$

SS&E

Tanker stores, supplies and equipment (SS&E) are assumed to vary both with vessel dwt (reflecting basically machinery SHP) and crew size. Variations occur also with the type of machinery plant, steam vs. diesel, etc., but have been ignored in this formulation.

TABLE 2E

REGULATION PACKAGE ALTERNATIVES FOR PRODUCT TANKERS

REQUIRED EQUIPMENT

| Regulation Alternative | SBT | CBT | DB | Second Radar | CAA | ICS | Emergency Steering Gear | DWT Lower Limit |
|---|---|---|---|---|---|---|---|---|
| 1 Existing | Reqd. | | | Reqd. | Reqd. | Reqd. | Reqd. | 5,000 |
| New | Reqd. | | | Reqd. | Reqd. | Reqd. | Reqd. | 5,000 |
| 2 Existing | | Reqd. | | Reqd. | Reqd. | Reqd. | Reqd. | 5,000 |
| New | Reqd. | | | Reqd. | Reqd. | Reqd. | Reqd. | 5,000 |
| 3 Existing | Reqd. | | | Reqd. | Reqd. | Reqd. | Reqd. | 20,000 |
| New | Reqd. | | Reqd. | Reqd. | Reqd. | Reqd. | Reqd. | 20,000 |
| 4 Existing | Reqd. | | | Reqd. | Reqd. | | Reqd. | 5,000 |
| New | Reqd. | | | Reqd. | Reqd. | | Reqd. | 5,000 |
| 5 Existing | | Reqd. | | Reqd. | Reqd. | | Reqd. | 5,000 |
| New | Reqd. | | | Reqd. | Reqd. | | Reqd. | 5,000 |

$$SS\&E \frac{(\$)}{(Day)} = (170 + 2.675 \frac{dwt}{1000}) \; (1 + .0125 \; (No. \; Crew - 25))$$

M&R

Maintenance and repair costs (M&R) are normally thought to be low in the first two years of operation then to rise rapidly until about the vessel's midlife of 12 years. These costs then would be expected to continue to rise but at a very normal rate. Much depends on the owner's practice, however. Actual values for M&R yearly cost were reviewed for some of the ships in the 36 categories and nc predictable variation with vessel age was discernable.

M&R costs also increase with the size and type of the machinery plant. Older tankers are generally slower vessels having smaller plants relative to their dwt and thus have lower M&R costs relative to vessel size. No variation in vessel age or machinery size and type was used in the formulation.

$$M\&R \frac{(\$)}{(Day)} = 730 + 8.88 \frac{(dwt)}{(1000)}$$

Insurance

Insurance costs consist of war risk, protection and indemnity (P&I) and hull insurance costs. P&I is based on a rate that varies with the experience of the vessels owned by groups of operators. The rate is applied to the gross registered tonnage of the vessel. This tonnage may change with the use of SBT since IMCO is encouraging the use of a deduction in GRT to cover the volume devoted to SBT.

Both war risk and hull insurance vary with the present value of the vessel. The rate for hull insurance varies additionally with the operator's experience. Older ships have lower values but generally have higher rates for hull because of increased risk. As a large part of the insurance is due to hull a formulation dependent only on dwt was used.

$$Insurance \frac{(\$)}{(Day)} = 120 + 14.5 \frac{dwt}{1000}$$

Other

These costs include overhead and other miscellaneous costs and are assumed to be a constant $90.4/day from vessel to vessel.

Port Charges

Port charges are very much dependent upon the voyage itinerary and the individual port's formula for assessing fees. Charges were assumed as a function of DWT.

$$Port \; Charges \frac{(\$)}{(Port)} = 1.3386 \frac{(dwt)}{(1000)} - .40714 \; dwt$$

### Fuel Costs

Fuel consumption while in port is minimal at loading ports since shoreside facilities handle the loading. In discharge ports the ship's pumps require a large amount of fuel. The inport fuel consumption used is thus an average value. A fuel price of $11.50/bbl for bunkers was used and no adjustment made for tankers requiring diesel oil. Generally diesel oil is more expensive while diesel machinery fuel rates are lower.

### Cargo Delivered

An average of 350 operating days per year was used to determine the cargo delivered. Port time per voyage was assumed as three days and cargo dwt carried (cdwt) as 0.94 of total dwt. Cdwt depends, however, upon the amount of fuel, stores and other miscellaneous dwt carried each voyage.

### Capital Costs

Capital costs were assumed to be completely amortized after 20 years of operation or 15 after rebuilding. These assumptions resulted in most of the existing fleet being amortized by the 1985 date for the demand and supply analysis.

Retrofit capital costs necessitated by the various alternatives were amortized under two situations:

Ships not Rebuilt - The period was assumed at 35 years minus the vessel's age in 1985.

Ships Rebuilt - 20 years minus the vessel's rebuilt age in 1985.

The period of amortization was further assumed to be not less than one year. Capital recovery factors were calculated based on a 10 percent return before taxes.

### Construction Costs (Retrofit)

The unit costs for some of the tanker safety and pollution prevention alternatives vary as a function of tanker deadweight. The following unit costs (as a function of deadweight) are required in the application of the evaluation procedure.

1. Percent DWT lost due to SBT retrofit.
2. SBT retrofit costs for existing product tankers.
3. SBT costs for new tankers.
4. Double bottom costs for new tankers.
5. Retrofit of Inert Gas Systems

The data sources and procedure used to obtain the above costs as a function of tanker deadweight are discussed below. All costs are for construction contracts in U. S. shipyards in 1978 dollars.

Capacity Loss Due to SBT Retrofit

For existing vessels to meet the requirements of SBT retrofit proposals, effective DWT cargo carrying capacity must also be lost due to the increased ballast volume. To estimate the effect that retrofitting SBT has on the U.S., and world fleets, a curve was developed relating percentage of effective cargo DWT lost upon retrofit of SBT versus tanker DWT. Figure 2E presents available data as taken from four sources:

1. Joint Greek, Italian, Norwegian Study, Reference 3.

2. French Study for OECD, Reference 4.

3. OECD Study, Reference 5.

4. MarAd Data based on the MarAd Pollution Report 1977, Reference 6, a Segregated Ballast Retrofit Study (a note submitted by the U. S. to Joint MSC/MEPC), Reference 7, and internal MarAd Studies.

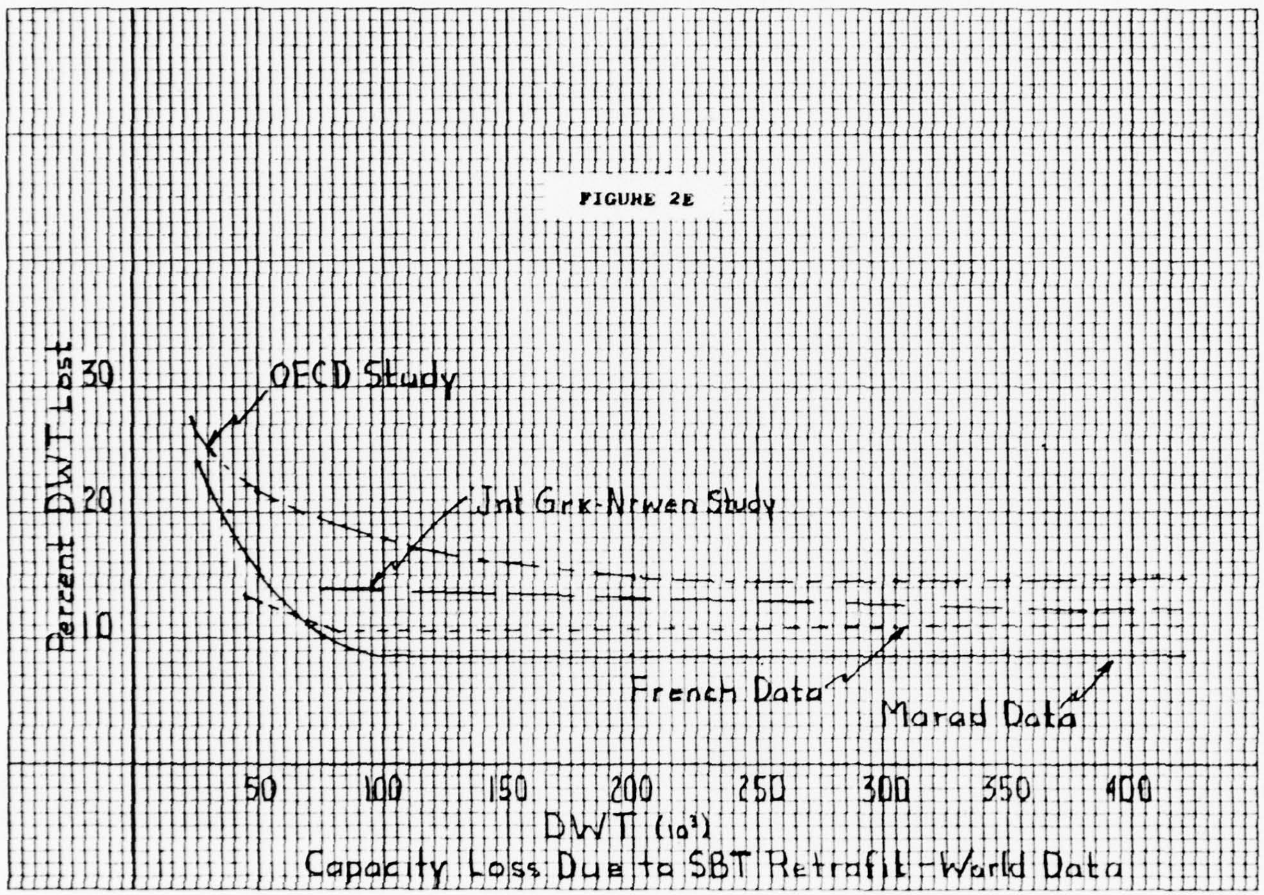
The shapes of the curves are similar. Comparison of the curves revealed that the French data closely approximated an average of all the curves for the range above 62,000 DWT. For this reason, the calculations of lost DWT for both U. S. and world fleets utilize the French curve for tanker DWT's above 62,000. Below 62,000 DWT, the MarAd data was considered more correct because it was based on data for tankers between 20,000 and 70,000 DWT. The other curves did not extend down to 20,000 DWT. Therefore, lost DWT calculations for both U. S. and world fleets between 20,000 and 62,000 were developed from the MarAd data.

The functional relationship between tanker capacity loss due to segregated ballast retrofit and tanker deadweight was presented in Figure 2E This figure gives the variation for tankers ranging in deadweight from 25,000 to 400,000 DWT. The lower range of the MarAd curve was extended in order to obtain the variation in capacity loss for tankers ranging in DWT from 2000 DWT to 40,000 DWT. The resulting curve is shown in Figure 3E.

SBT Retrofit for Product Tankers

The costs for retrofitting product tankers with segregated ballast are presented in Figure 4E were obtained from extending the data in Figure 3 of Reference 4. The SBT retrofit costs for seven Maritime Administration design ships form the basis for the cost figures presented. These values compare favorably with data in References 4 and 5 as presented on the Figure. In each case, the cost estimate includes shipyard services, piping, and structural changes required for the minimum ballast draft SBT retrofit. Structural changes in each case include new bulkheads only. Cost for any forward bottom strengthening which the classification societies may require

FIGURE 2E




Capacity Loss Due to SBT Retrofit - World Data

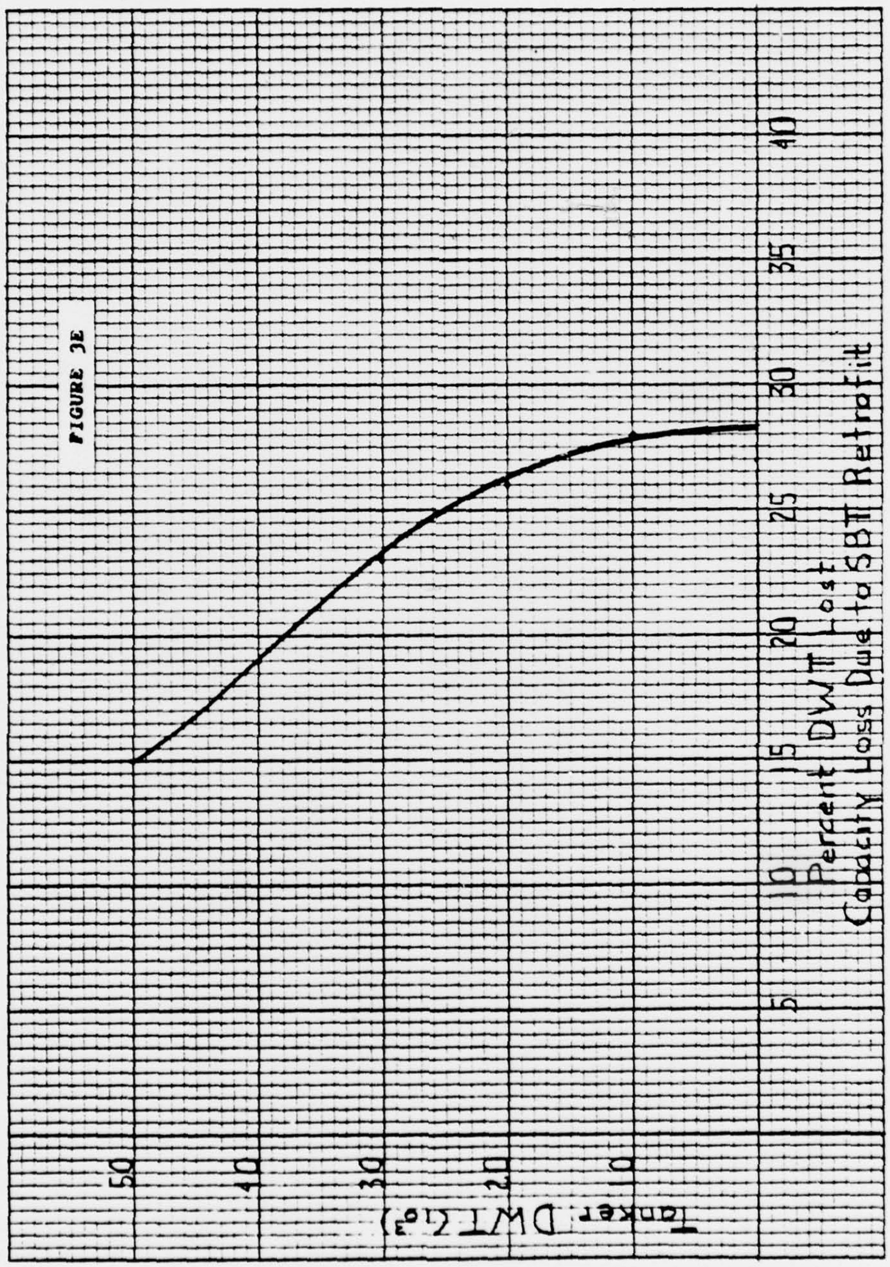

Tanker DWT (10³)
50
40
30
20
10
5
10
15
20
25
30
35
40
Percent DWT Lost
Capacity Loss Due to SBT Retrofit

FIGURE 3E

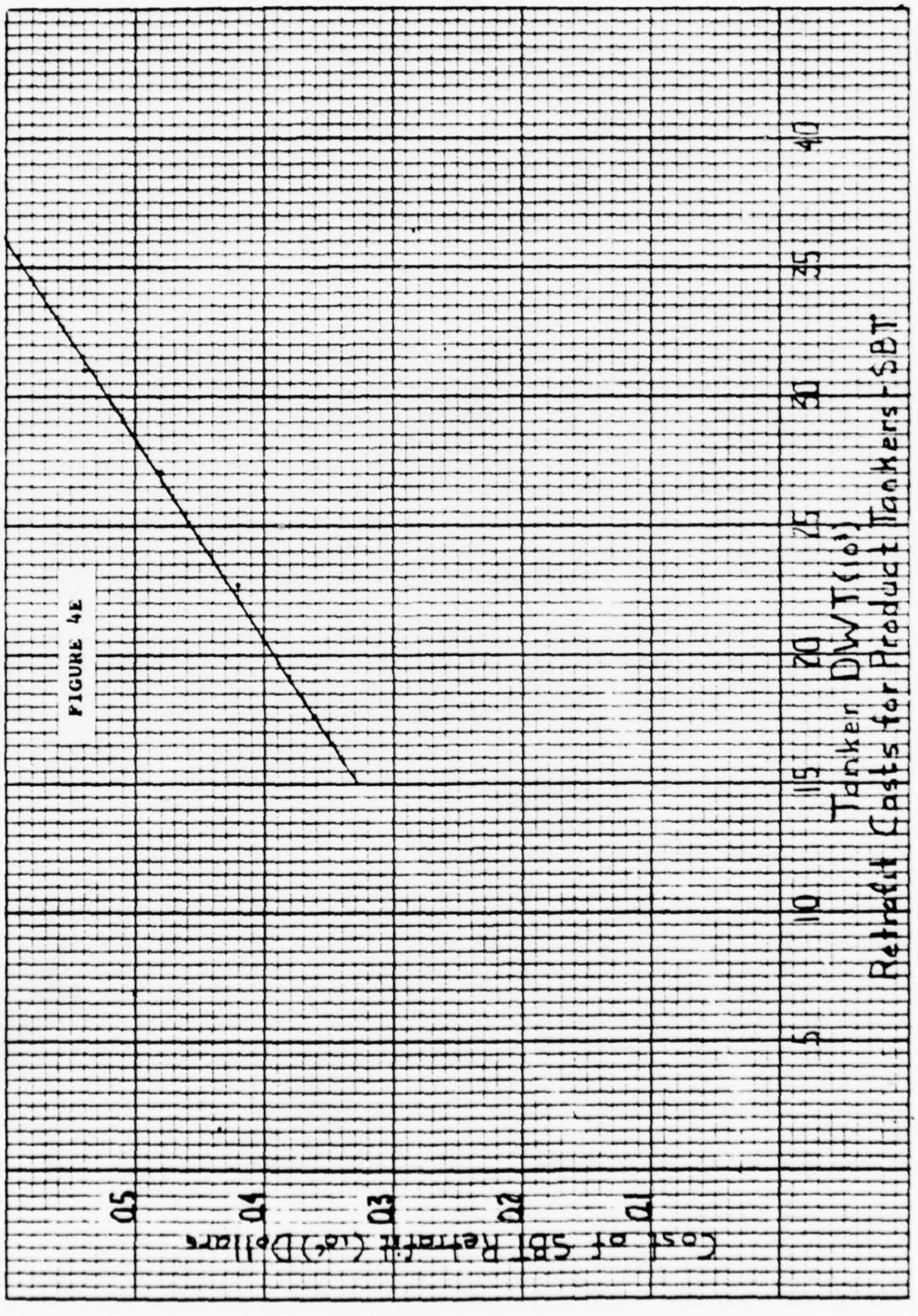

Cost of SBT Retrofit (10^6) Dollars
0.5
0.4
0.3
0.2
0.1
5
10
15
20
25
30
35
40
Tanker DWT (10^3)
Retrofit Costs for Product Tankers - SBT

FIGURE 4E

have not been included, because hull strengths after retrofit have not been calculated.

Tank cleaning and gas freeing costs are not included, as this work is done by the ship operator before the ship arrives in the yard. Separate estimates are given for retrofits with and without tank coating costs.

It was assumed that new segregated ballast tanks will be completely coated internally, in keeping with sound marine corrosion protection practice. No sacrificial anodes have been installed in the new segregated ballast tanks, though some owners may add anodes to supplement corrosion protection by coatings.

SBT Costs for New Tankers

The costs of segregated ballast for new tankers were obtained by an extension of data presented in Table II-6 of Reference 6. The costs for the IMCO segregated ballast tankers (shown in the table) ranging in DWT from 35,100 DWT to 225,000 DWT were plotted in order to obtain an indication of how the cost varied for tankers with DWT capacities ranging from 2,000 DWT to 40,000 DWT. The plotted costs (Figure 5E) show that costs of segregated ballast for new tankers decrease as DWT decreases and reach a minimum at approximately 55,800 DWT then start to increase again as DWT is decreased below 55,800 DWT. The smallest DWT tanker shown in Table II-6 is 31,000 DWT.

To estimate costs for tankers as small as 2,000 DWT, it was assumed that these costs would increase linearly from the minimum cost and a line was drawn from the minimum cost through the mid-point of the cost for the 39,700 DWT and the 35,100 DWT tankers. This line is shown in Figure 5E as a broken line. For convenience in reading values for calculations, the broken line was replotted using an expanded scale for DWT. This plot is shown in Figure 6E.

Double Bottom Costs for New Tankers

The costs of double bottoms for new tankers were obtained from Table II-6 of Reference 6. The costs given in the table include the cost for segregated ballast. In order to obtain the cost for double bottoms only it is necessary to subtract the cost of segregated ballast from the costs shown in Table II-6. The costs for double bottoms only are shown in Figure 6. These costs represent only the cost of double bottom structure and do not account for the vessels loss in cargo capacity from the double bottom volume.) The costs for double bottoms plus segregated ballast (as given in Table II-6) are also shown in Figure 7E. These costs include constructing the vessel larger to give equal cargo capacity.

Inert Gas Systems (IGS)

Independent plant inert gas systems were considered in the unit costs for these systems. The cost of IGS retrofit increases with vessels size. The average estimated per-vessels cost for IGS hardware and installation is about $1,000,000 for vessels ranging in deadweight from 20,000 DWT to 40,000 DWT and about $850,000 for vessels ranging in deadweight from 15,000 DWT to 20,000 DWT.

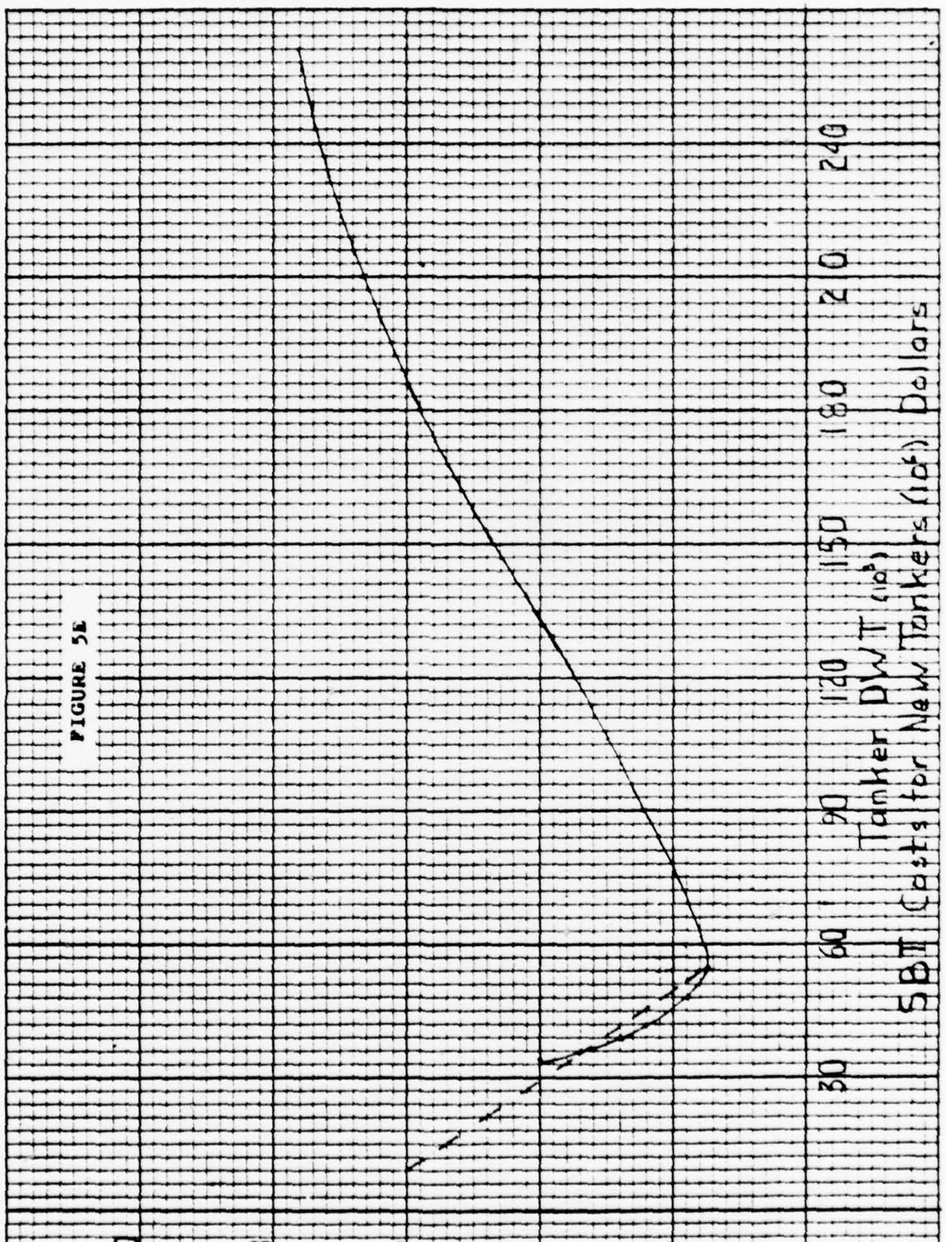
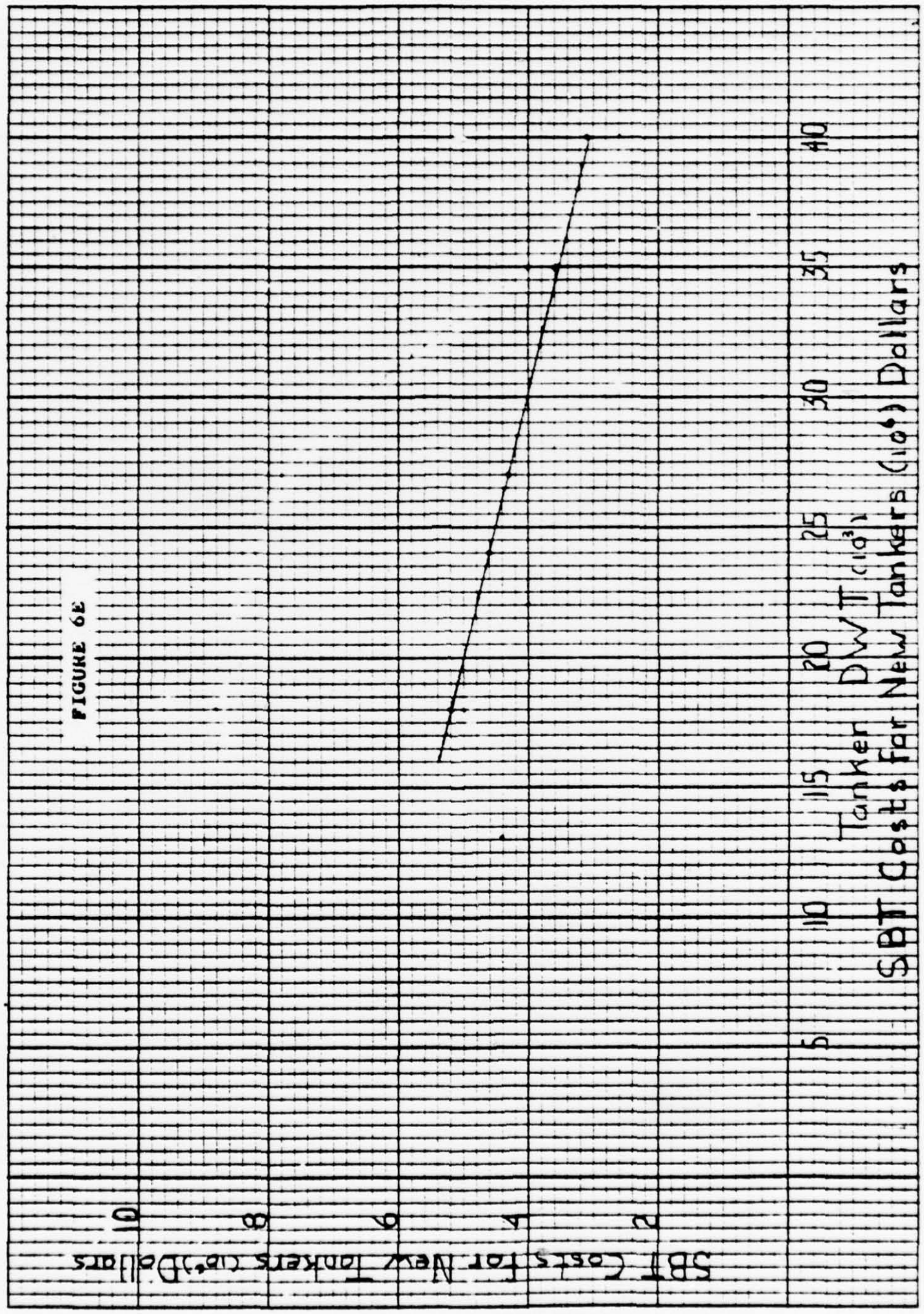

SBT Costs for New Tankers (10^6) Dollars
10
8
6
4
2
30
60
90
120
150
180
210
240
Tanker DWT (10^3)
SBT Costs for New Tankers (10^6) Dollars

FIGURE 5E

FIGURE 6E


SBT Costs for New Tankers (10⁶) Dollars
10
8
6
4
2
5
10
15
20
25
30
35
40
Tanker DWT (10³)
SBT Costs for New Tankers (10⁶) Dollars

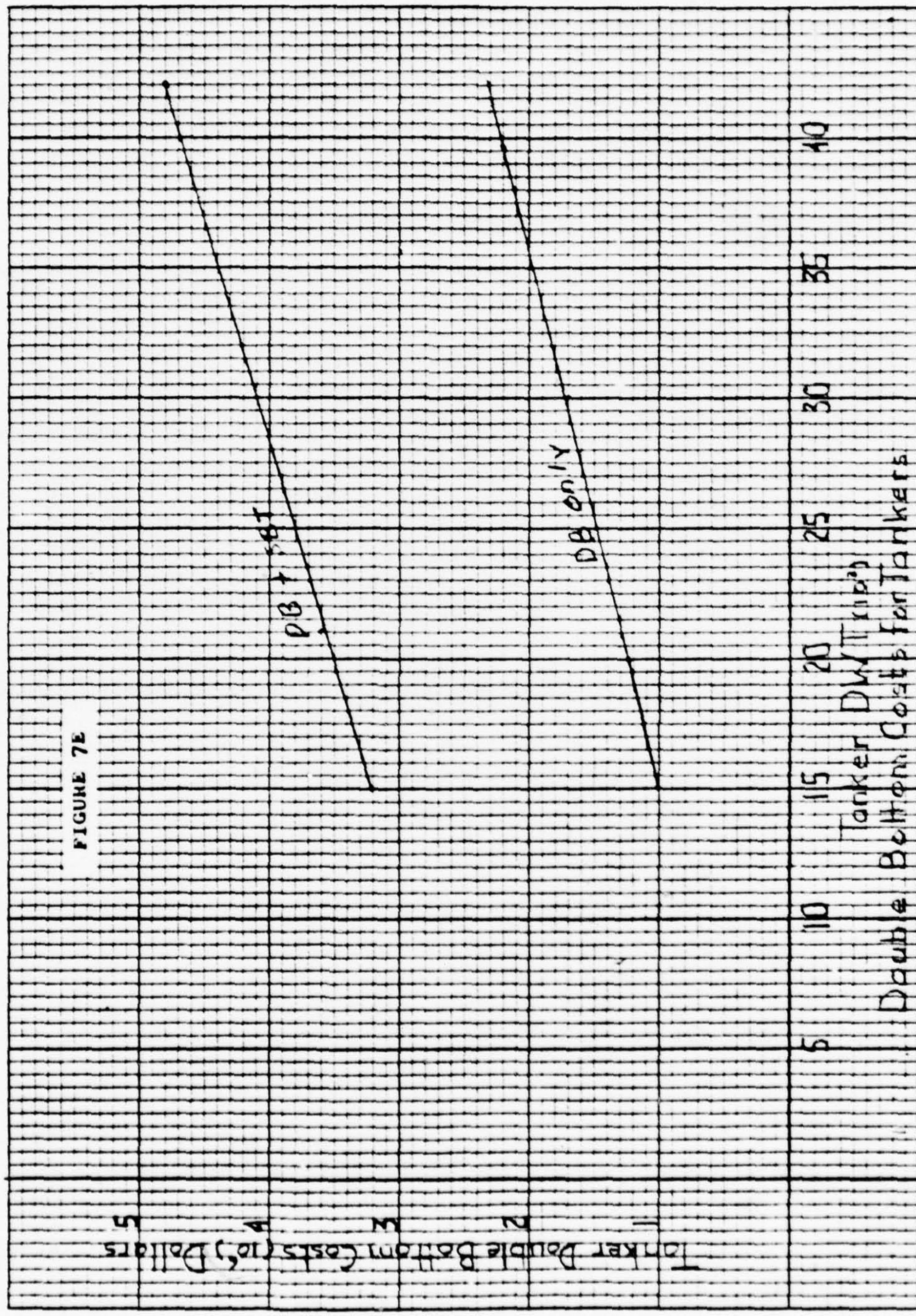


FIGURE 7E
DB + SBT
DB only
Tanker Double Bottom Costs ($10^6$) Dollars
1
2
3
4
5
5
10
15
20
25
30
35
40
Tanker DWT ($x10^3$)
Double Bottom Costs for Tankers

## Other Unit Costs for Regulatory Alternatives

The installation costs for a secondary radar vary as a function of deadweight. Since this variation is small, the average per-vessel cost for a secondary radar was assumed to remain constant at about \$50,000. Similarly for the collision avoidance assist subsystem; the average per-vessel cost was estimated to be about \$150,000. Steering modifications are already required of U. S. tankers and additional cost is not necessary. This modification is estimated to cost about \$20,000 per vessel.

## Total Capital Costs of Regulation Alternatives

The regulation alternatives for existing product tankers considered in this analysis are shown in Table 2E. Alternatives 1E and 3E are identical except that 3E has a deadweight limit of 20,000 DWT instead of the 5000 deadweight limit for 1E. The variation of the unit costs with deadweight were described previously. These unit costs were used to compute the total capital costs incurred by imposing each regulation alternative shown in Table A to the product tanker population included within the imposed deadweight limit shown in Table 2E. These calculations were effected for one assumed product tanker life cycle scenario of 35 years for each product tanker. The calculations for each alternative considered the 36 possible categories of DWT for product tankers. Each DWT category was described by three additional parameters. These are average deadweight, number of tankers in the category and amortization period based on tanker age since built or since rebuilt.

The total capital costs for each regulation alternative were computed as follows:

$$(AP)_{jv} = \left[C_{ron} + \sum_{i=1}^{S} Csi\right] (CRF)_{j} \quad \ldots (1)$$

$$(TCC)_{j} = N_{j} P_{j} (AP)_{jv} \quad \ldots\ldots\ldots\ldots (2)$$

$$TRAC\ (x) = \sum_{j=1}^{C(x)} (TCC)_{J} \quad \ldots\ldots\ldots\ldots (3)$$

Where:

$(AP)_{jv}$ = annual payment for each vessel in category j.

$C_{ron}$ = cost of retrofit or new construction for regulation alternative.

$C_{si}$ = cost of each safety subsystem

$i = 1, 2, \ldots\ldots S$

S = 4 possible safety subsystems

$(CRF)_j$ = capital recovery factor for jth category.

$(TCC)_j$ = total capital costs for category j.

$N_j$ = number of tankers in category j.

$P_j$ = amortization period (in years) for category j.

TRAC (x) = total capital costs for all categories used in regulation alternative x.

C (x) = number of categories (or fraction thereof) used in regulation alternative x.

C (x) = 1, 2, ..... 36

X = 1E, 2E, ..... 5E (regulation alternatives).

The resulting capital costs for each regulation alternative and the components in each regulatory package are shown in Table 3E. The average costs (in millions) per vessel for each regulation alternative one through five are \$2.42, \$1.61, \$2.06, \$0.77, and \$0.00 respectively.

Construction of Supply Curves

The RFR's calculated for the representative average vessels in each of the categories for the fleet are next plotted as bars on the supply curve. The base supply curve for 1985 is shown in Figure 8E where the height of each bar represents the average RFR of the vessels in that category. The width of each bar represents the total deadweight carrying capacity of all of the vessels in the category. The bars are arranged so that the vessel groups with the most economical costs (lowest RFR's) are grouped to the left.

The base supply function as presented shows the present U. S. tank fleet operating in 1985. Vessels falling in the furthest right bars are less competitive due to their high annual operating costs. If demand for oil transportation is lower in 1985, these vessels are assumed to switch into non-oil trade or to be scrapped.

The number of ships to be built or scrapped is thus decided from this curve when demand for tonnage is determined.

A similar supply function is constructed for each regulatory option package considered. For each category of vessels, the RFR increases as a result of the cost of compliance. The total deadweight tonnage in each category decreases because of retrofit capacity losses. The categories are rearranged in increasing order of their new RFRs. The primary reason why order changes from the base case is that the amortization period for capital costs varies among the categories.

FIGURE 8E

1985 TANKER DEMAND AND SUPPLY
UNDER VARIOUS REGULATORY SCENARIOS

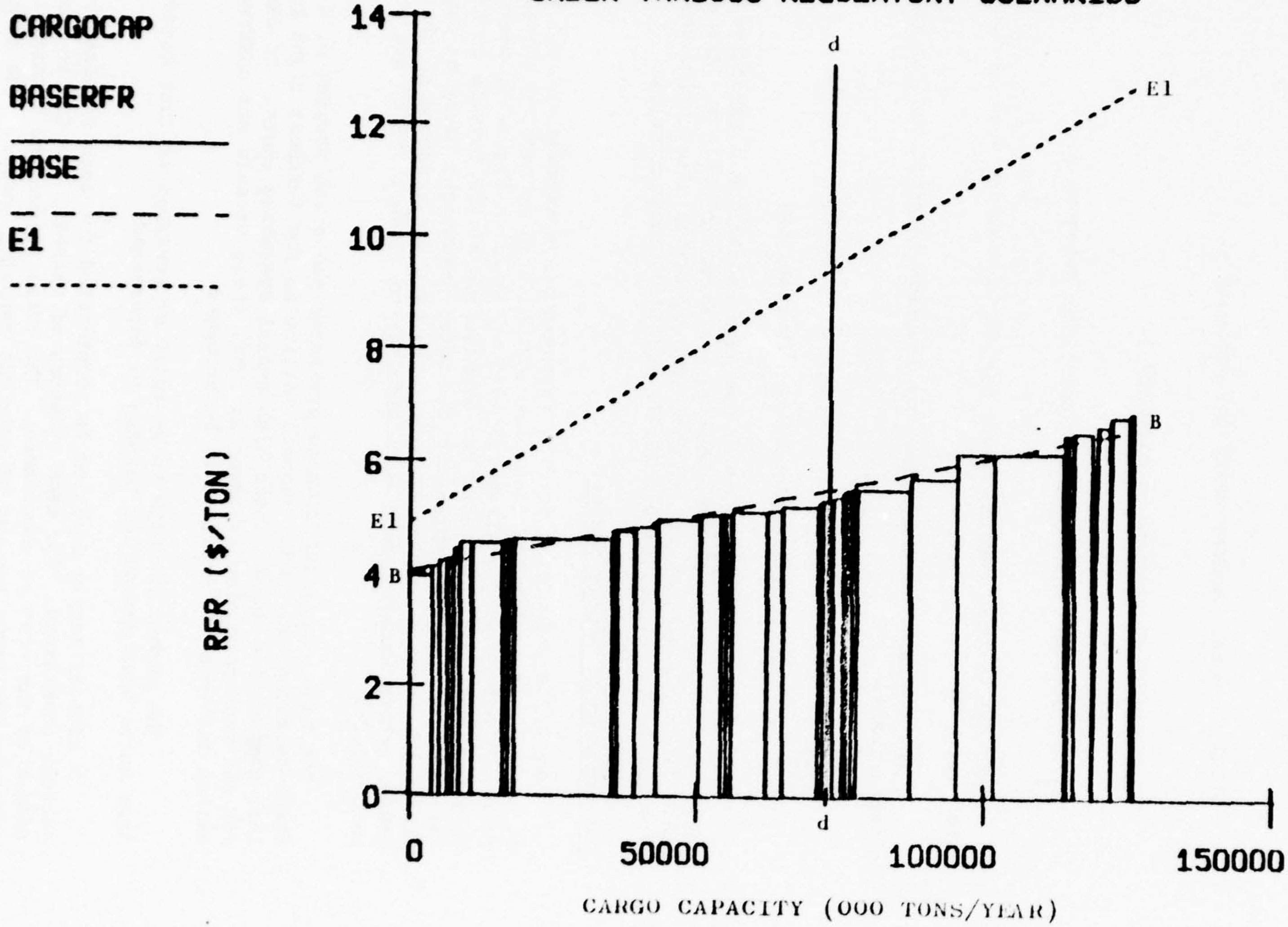


TABLE 3E

| Alternative | Components | SBT | CBT | DB | $2^{nd}$ Radar + CAA | IGS | E. Steer. Gear | Total (million) |
|---|---|---|---|---|---|---|---|---|
| 1 | E | 71.76 | | | 0 | 143.43 | 0 | $215.19 |
| | N | | | | | | | |
| 2 | E | | 0 | | 0 | 143.43 | 0 | $143.43 |
| | N | | | | | | | |
| 3 | E | 65.87 | | | 1.76 | 142.96 | 0 | $210.59 |
| | N | | | | | | | |
| 4 | E | 71.22 | 0 | | 0 | | 0 | $71.22 |
| | N | | | | | | | |
| 5 | E | | 0 | | 0 | 0 | 0 | $00.00 |
| | N | | | | | | | |

Resulting Capital Costs for Regulation Alternatives

## Conclusion

Private sector costs. For consumers and for the economy as a whole, the most meaningful way to view the cost of the regulations is the amount they add to the annual cost of transporting a given quantity of oil. A supply and demand equilibrium model was used to determine the total annual cost for each regulatory alternative and a hypothetical base case if no additional regulations were imposed. The time period of the analysis is after the completion of retrofitting and after projected reductions in tanker demand due to expected pipeline developments. 1985 was chosen as the time when these changes would, be completed. Table 4E shows the annual costs for the five regulatory alternative and compares them to a base case. The base case includes the costs of equipment standards already required by the 1978 IMCO Protocols. The total annual cost includes amortized capital costs and capacity loss due to retrofitting.

TABLE 4E

COST SUMMARY
1985 ANNUAL COSTS
(millions)

| Alternative | Total Transport Cost | Increase from Base Case | % Increase |
|---|---|---|---|
| BASE | $345.2 | | |
| 1E | 498.5 | $153.2 | 44% |
| 2E | 486.1 | 140.8 | 41% |
| 3E | 461.8 | 116.5 | 34% |
| 4E | 472.9 | 127.6 | 37% |
| 5E | 455.6 | 110.3 | 32% |

## Impact on Cargo Carrying Capacity

The five regulatory alternatives considered require either segregated ballast or clean ballast on existing tankers. Both requirements involve the dedication of some cargo space for the separate carriage of ballast, reducing the amount of cargo a ship can carry on any one voyage. At the same time, segregated ballast and clean ballast arrangements increase vessel speed and partially offset the loss of cargo space by enabling a ship to make more voyages during the year. For alternative 1E, some ships would lose cargo capacity during remeasurement to below 20,000 DWT to avoid compliance with the regulations. This capacity loss is considered in the calculations below.

Table 5E summarizes the impact of segregated ballast, clean ballast and/or remeasurement on annual effective cargo capacity. The reduction in cargo carrying capacity for those ships which comprise the projected 1985 fleet for each alternative is measured from the capacity of those same ships without new regulatory action (i.e., the base case).

Although these capacity reductions do not involve a physical outlay of capital at the time of retrofit, they strongly influence the cost of ship operations. A 21 percent capacity reduction reflects, in a sense, a 21 percent reduction in productivity. Unit costs - the RFR or cost per ton of cargo carried - increase by an equivalent percentage amount. Increased operating costs resulting from capacity reductions must be considered with the more visible capital costs in evaluating the overall impact of each regulatory alternative. Both influence the RFR and both contribute to the total cost estimates.

TABLE 5E

CAPACITY REDUCTION - 1985 FLEET

| Alternative | Reduction in Effective Cargo Capacity (%)* |
|---|---|
| Base | |
| 1E | 21% |
| 2E | 21 |
| 3E | 21 |
| 4E | 21 |
| 5E | 22 |

*weighted average reduction for all ships in the 1985 fleet. Effective cargo capacity in all cases, including the base case, is defined as (DWT x .94 x trips per year).

## Long-Term Cost Impact

In theory, annual costs would eventually increase over the 1985 levels. This would occur gradually as currently existing ships are replaced by new construction. The value of the theoretical long-term level of annual costs could be calculated from the model, but it would not be meaningful in any practical way. The long-term forecast depends on unrealistic assumptions of constant demand levels, unchanged technology, and constant relative costs of resources.

## Public Sector Costs

In addition to the annual cost of the regulations for small tankers in the domestic trade, the cost of bringing the long-term MSC charter fleet into compliance with additional regulations must be considered. This cost

would be borne by the public as taxpayers rather than as consumers. This fleet consists of 13 ships of an aggregate 385,000 DWT. Because these vessels tend to be in dedicated service, and because of the long-term charters, these vessels were not included in the analysis.

Inflationary Impact Considerations

The major shortcoming of the concept of annualized costs, used in the preceding analysis, is that it understates the impact on the economy of a capital expenditure when it is made. The capital outlay increases the demand for shipbuilding and its input resources, and it also increases the demand for credit in the money market. The result of increasing demand depends on the levels of demand for these resources which would otherwise exist. The expenditure might merely reduce the unemployment in shipyard communities while, at the same time, it might increase steel prices or interest rates. The scope of this study does not permit an analysis of differential impacts. However, we can estimate the magnitude of capital outlays and their time frame. The reader can judge their significance relative to the aggregate economy or particular sectors.

The method of forecasting does not tell when the changes occur during the interval between imposing regulations and 1985. Additional assumptions are needed to predict annual outlay levels. Uncertainty of decreasing demand would induce shipowners to delay investment decisions as long as possible, but this is diminished by the tendency toward long-term charter agreements. The efficiency of retrofitting during regular shipyard overhaul periods tends to make retrofitting more uniform over time. Shipyard capacity and advance contracting arrangements also induce more uniform expenditures. With conflicting trends, the convenient assumption may be made that capital outlay will be uniform over the period (1981-1985).

TABLE 6E

BASE CASE

| GROUP | RFR | DWT CAPACITY* | CUMULATIVE CAPACITY | COST** | CUMULATIVE COST |
|---|---|---|---|---|---|
| 31 | 3.97 | 3,742.363 | 3,742.363 | 14,857.180 | 14,857.180 |
| 33 | 4.11 | 1,298.571 | 5,040.933 | 5,337.125 | 20,194.305 |
| 34 | 4.22 | 1,226.790 | 6,267.724 | 5,177.055 | 25,371.360 |
| 26 | 4.24 | 1,102.806 | 7,370.530 | 4,675.898 | 30,047.258 |
| 35 | 4.43 | 1,164.798 | 8,535.328 | 5,160.056 | 35,207.314 |
| 25 | 4.53 | 2,117.518 | 10,652.846 | 9,592.358 | 44,799.671 |
| 29 | 4.54 | 5,321.529 | 15,974.375 | 24,159.741 | 68,959.413 |
| 27 | 4.56 | 991.873 | 16,966.248 | 4,522.941 | 73,482.354 |
| 22 | 4.58 | 1,066.916 | 18,033.164 | 4,886.475 | 78,368.829 |
| 24 | 4.60 | 16,917.307 | 34,950.471 | 77,819.612 | 156,188.441 |
| 30 | 4.65 | 1,086.492 | 36,036.963 | 5,052.190 | 161,240.630 |
| 28 | 4.74 | 3,070.238 | 39,107.202 | 14,552.930 | 175,793.560 |
| 23 | 4.82 | 3,944.653 | 43,051.854 | 19,013.226 | 194,806.786 |
| 12 | 4.95 | 7,334.640 | 50,386.494 | 36,306.466 | 231,113.251 |
| 13 | 5.02 | 3,735.837 | 54,122.331 | 18,753.903 | 249,867.155 |
| 10 | 5.04 | 907.042 | 55,029.373 | 4,571.490 | 254,438.645 |
| 11 | 5.05 | 926.618 | 55,955.991 | 4,679.422 | 259,118.067 |
| 16 | 5.09 | 6,166.579 | 62,122.570 | 31,387.885 | 290,505.952 |
| 17 | 5.12 | 2,763.541 | 64,886.110 | 14,149.329 | 304,655.281 |
| 14 | 5.18 | 6,091.536 | 70,977.646 | 31,554.154 | 336,209.435 |
| 18 | 5.25 | 867.889 | 71,845.535 | 4,556.416 | 340,765.851 |
| 19 | 5.30 | 1,781.456 | 73,626.991 | 9,441.717 | 350,207.568 |
| 9 | 5.36 | 1,641.158 | 75,268.149 | 8,796.608 | 359,004.176 |
| 7 | 5.44 | 763.481 | 76,031.630 | 4,153.338 | 363,157.514 |

* Units of capacity are 1,000 tons/year
** Units of cost are $1,000/year

BASE CASE

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 20 | 5.47 | 897.253 | 76,928.884 | 4,907.977 | 368,065.490 |
| 21 | 5.48 | 822.210 | 77,751.094 | 4,505.713 | 372,571.204 |
| 15 | 5.49 | 9,351.013 | 87,102.107 | 51,337.060 | 423,908.264 |
| 8 | 5.70 | 8,147.062 | 95,249.169 | 46,438.252 | 470,346.517 |
| 32 | 6.13 | 6,463.488 | 101,712.657 | 39,621.181 | 509,967.698 |
| 36 | 6.13 | 12,280.953 | 113,993.610 | 75,282.244 | 585,249.942 |
| 4 | 6.46 | 535.089 | 114,528.699 | 3,456.677 | 588,706.619 |
| 1 | 6.47 | 1,083.230 | 115,611.929 | 7,008.496 | 595,715.115 |
| 2 | 6.52 | 3,138.756 | 118,750.685 | 20,464.688 | 616,179.803 |
| 6 | 6.63 | 3,269.265 | 122,019.951 | 21,675.230 | 637,855.033 |
| 3 | 6.79 | 3,393.250 | 125,413.200 | 23,040.165 | 660,895.198 |
| 5 | 6.86 | 600.344 | 126,013.544 | 4,118.361 | 665,013.559 |

ALTERNATIVE E1

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 33 | 5.30 | 1,063.720 | 1,063.720 | 5,637.718 | 5,637.718 |
| 34 | 5.41 | 998.680 | 2,062.400 | 5,402.859 | 11,040.577 |
| 35 | 5.58 | 938.719 | 3,001.120 | 5,238.054 | 16,278.632 |
| 31 | 5.81 | 3,046.505 | 6,047.625 | 17,700.196 | 33,978.828 |
| 25 | 5.96 | 1,669.934 | 7,717.559 | 9,952.806 | 43,931.634 |
| 26 | 5.97 | 880.917 | 8,598.476 | 5,259.073 | 49,190.707 |
| 22 | 6.05 | 855.518 | 9,453.994 | 5,175.885 | 54,366.593 |
| 24 | 6.10 | 13,341.343 | 22,795.337 | 81,382.193 | 135,748.785 |
| 27 | 6.15 | 774.143 | 23,569.480 | 4,760.980 | 140,509.765 |
| 29 | 6.72 | 4,196.681 | 27,766.161 | 28,201.694 | 168,711.460 |
| 13 | 6.75 | 2,900.555 | 30,666.716 | 19,578.744 | 188,290.204 |
| 23 | 6.75 | 3,078.710 | 33,745.426 | 20,781.294 | 209,071.497 |
| 30 | 6.76 | 867.902 | 34,613.328 | 5,867.018 | 214,938.516 |
| 10 | 6.92 | 699.607 | 35,312.935 | 4,841.282 | 219,779.798 |
| 14 | 6.99 | 4,679.952 | 39,992.887 | 32,712.861 | 252,492.659 |
| 28 | 7.08 | 2,414.993 | 42,407.880 | 17,098.150 | 269,590.810 |
| 12 | 7.17 | 5,672.290 | 48,080.170 | 40,670.321 | 310,261.131 |
| 19 | 7.19 | 1,368.637 | 49,448.807 | 9,840.497 | 320,101.628 |
| 16 | 7.44 | 4,737.588 | 54,186.395 | 35,247.656 | 355,349.284 |
| 21 | 7.59 | 627.495 | 54,813.890 | 4,762.688 | 360,111.972 |
| 32 | 7.61 | 5,294.565 | 60,108.455 | 40,291.638 | 400,403.610 |
| 18 | 7.65 | 666.772 | 60,775.226 | 5,100.803 | 405,504.413 |
| 36 | 7.72 | 9,997.425 | 70,772.651 | 77,180.120 | 482,684.533 |
| 9 | 7.88 | 1,252.500 | 72,025.152 | 9,869.701 | 492,554.235 |

ALTERNATIVE E1

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 11 | 8.86 | 716.606 | 72,741.758 | 6,349.130 | 498,903.364 |
| 17 | 8.95 | 2,137.202 | 74,878.959 | 19,127.957 | 518,031.321 |
| 20 | 9.52 | 689.348 | 75,568.308 | 6,562.595 | 524,593.916 |
| 15 | 9.69 | 7,155.536 | 82,723.844 | 69,337.144 | 593,931.060 |
| 8 | 10.08 | 6,217.680 | 88,941.524 | 62,674.213 | 656,605.273 |
| 3 | 10.27 | 2,530.963 | 91,472.487 | 25,992.994 | 682,598.267 |
| 7 | 10.28 | 578.790 | 92,051.276 | 5,949.957 | 688,548.224 |
| 5 | 10.88 | 449.008 | 92,500.284 | 4,885.203 | 693,433.426 |
| 2 | 11.73 | 2,347.529 | 94,847.813 | 27,536.515 | 720,969.941 |
| 4 | 12.37 | 397.480 | 95,245.293 | 4,916.827 | 725,886.769 |
| 1 | 12.41 | 804.655 | 96,049.948 | 9,985.763 | 735,872.532 |
| 6 | 12.49 | 2,351.978 | 98,401.925 | 29,376.204 | 765,248.736 |

ALTERNATIVE E2

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 33 | 5.16 | 1,063.720 | 1,063.720 | 5,488.797 | 5,488.797 |
| 34 | 5.29 | 998.680 | 2,062.400 | 5,283.018 | 10,771.815 |
| 35 | 5.48 | 938.719 | 3,001.120 | 5,144.182 | 15,915.997 |
| 31 | 5.69 | 3,046.505 | 6,047.625 | 17,334.616 | 33,250.613 |
| 26 | 5.71 | 880.917 | 6,928.542 | 5,030.035 | 38,280.648 |
| 25 | 5.84 | 1,669.934 | 8,598.476 | 9,752.414 | 48,033.062 |
| 22 | 5.90 | 855.518 | 9,453.994 | 5,047.557 | 53,080.619 |
| 24 | 5.97 | 13,341.343 | 22,795.337 | 79,647.818 | 132,728.437 |
| 27 | 6.01 | 774.143 | 23,569.480 | 4,652.600 | 137,381.037 |
| 23 | 6.50 | 3,078.710 | 26,648.191 | 20,011.616 | 157,392.653 |
| 29 | 6.61 | 4,196.681 | 30,844.871 | 27,740.060 | 185,132.713 |
| 13 | 6.61 | 2,900.555 | 33,745.426 | 19,172.667 | 204,305.379 |
| 30 | 6.65 | 867.902 | 34,613.328 | 5,771.549 | 210,076.929 |
| 28 | 6.70 | 2,414.993 | 37,028.321 | 16,180.453 | 226,257.382 |
| 10 | 6.76 | 699.607 | 37,727.928 | 4,729.345 | 230,986.727 |
| 14 | 6.87 | 4,679.952 | 42,407.880 | 32,151.267 | 263,137.994 |
| 12 | 6.88 | 5,672.290 | 48,080.170 | 39,025.357 | 302,163.351 |
| 19 | 7.05 | 1,368.637 | 49,448.807 | 9,648.888 | 311,812.239 |
| 16 | 7.14 | 4,737.588 | 54,186.395 | 33,826.379 | 345,638.618 |
| 18 | 7.35 | 666.772 | 54,853.167 | 4,900.772 | 350,539.390 |
| 21 | 7.43 | 627.495 | 55,480.662 | 4,662.289 | 355,201.679 |
| 32 | 7.53 | 5,294.565 | 60,775.226 | 39,868.073 | 395,069.752 |
| 9 | 7.58 | 1,252.500 | 62,027.727 | 9,493.951 | 404,563.703 |
| 36 | 7.62 | 9,997.425 | 72,025.152 | 76,180.378 | 480,744.081 |

ALTERNATIVE E2

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 11 | 7.91 | 716.606 | 72,741.758 | 5,668.354 | 486,412.435 |
| 17 | 8.18 | 2,137.202 | 74,878.959 | 17,482.312 | 503,894.746 |
| 20 | 8.74 | 689.348 | 75,568.308 | 6,024.903 | 509,919.650 |
| 15 | 8.89 | 7,155.536 | 82,723.844 | 63,612.715 | 573,532.365 |
| 8 | 9.26 | 6,217.680 | 88,941.524 | 57,575.715 | 631,108.080 |
| 7 | 9.45 | 578.790 | 89,520.313 | 5,469.561 | 636,577.641 |
| 3 | 9.91 | 2,530.963 | 92,051.276 | 25,081.847 | 661,659.488 |
| 5 | 9.92 | 449.008 | 92,500.284 | 4,454.156 | 666,113.644 |
| 2 | 11.01 | 2,347.529 | 94,847.813 | 25,846.294 | 691,959.938 |
| 4 | 11.41 | 397.480 | 95,245.293 | 4,535.247 | 696,495.184 |
| 1 | 11.47 | 804.655 | 96,049.948 | 9,229.388 | 705,724.572 |
| 6 | 11.58 | 2,351.978 | 98,401.925 | 27,235.904 | 732,960.476 |

ALTERNATIVE E3

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 33 | 5.30 | 1,063.720 | 1,063.720 | 5,637.718 | 5,637.718 |
| 34 | 5.41 | 998.680 | 2,062.400 | 5,402.859 | 11,040.577 |
| 35 | 5.58 | 938.719 | 3,001.120 | 5,238.054 | 16,278.632 |
| 31 | 5.81 | 3,046.505 | 6,047.625 | 17,700.196 | 33,978.828 |
| 25 | 5.96 | 1,669.934 | 7,717.559 | 9,952.806 | 43,931.634 |
| 26 | 5.97 | 880.917 | 8,598.476 | 5,259.073 | 49,190.707 |
| 22 | 6.05 | 855.518 | 9,453.994 | 5,175.885 | 54,366.593 |
| 24 | 6.10 | 13,341.343 | 22,795.337 | 81,382.193 | 135,748.785 |
| 27 | 6.15 | 774.143 | 23,569.480 | 4,760.980 | 140,509.765 |
| 7 | 6.15 | 652.548 | 24,222.028 | 4,013.170 | 144,522.935 |
| 6 | 6.30 | 3,262.740 | 27,484.768 | 20,555.262 | 165,078.197 |
| 9 | 6.39 | 1,305.096 | 28,789.864 | 8,339.563 | 173,417.761 |
| 4 | 6.46 | 535.089 | 29,324.954 | 3,456.677 | 176,874.438 |
| 1 | 6.47 | 1,083.230 | 30,408.183 | 7,008.496 | 183,882.934 |
| 16 | 6.49 | 4,567.836 | 34,976.019 | 29,645.256 | 213,528.190 |
| 2 | 6.52 | 3,138.756 | 38,114.775 | 20,464.608 | 233,992.878 |
| 11 | 6.54 | 652.548 | 38,767.323 | 4,267.664 | 238,260.542 |
| 12 | 6.54 | 5,220.384 | 43,987.707 | 34,141.311 | 272,401.853 |
| 13 | 6.54 | 2,610.192 | 46,597.899 | 17,070.656 | 289,472.509 |
| 8 | 6.55 | 6,525.480 | 53,123.379 | 42,741.894 | 332,214.403 |
| 15 | 6.57 | 7,178.028 | 60,301.407 | 47,159.644 | 379,374.047 |
| 17 | 6.59 | 1,957.644 | 62,259.051 | 12,900.874 | 392,274.921 |
| 14 | 6.60 | 4,567.836 | 66,826.887 | 30,147.718 | 422,422.638 |
| 18 | 6.60 | 652.548 | 67,479.435 | 4,306.817 | 426,729.455 |

ALTERNATIVE E3

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 10 | 6.65 | 652.548 | 68,131.983 | 4,339.444 | 431,068.899 |
| 29 | 6.72 | 4,196.681 | 72,328.664 | 28,201.694 | 459,270.594 |
| 21 | 6.73 | 652.548 | 72,981.212 | 4,391.648 | 463,662.242 |
| 23 | 6.75 | 3,078.710 | 76,059.922 | 20,781.294 | 484,443.536 |
| 30 | 6.76 | 867.902 | 76,927.824 | 5,867.018 | 490,310.554 |
| 3 | 6.79 | 3,393.250 | 80,321.074 | 23,040.165 | 513,350.719 |
| 5 | 6.86 | 600.344 | 80,921.418 | 4,118.361 | 517,469.080 |
| 19 | 6.89 | 1,305.096 | 82,226.514 | 8,992.111 | 526,461.191 |
| 20 | 6.90 | 652.548 | 82,879.062 | 4,502.581 | 530,963.772 |
| 28 | 7.08 | 2,414.993 | 85,294.055 | 17,098.150 | 548,061.923 |
| 32 | 7.61 | 5,294.565 | 90,588.620 | 40,291.638 | 588,353.561 |
| 36 | 7.72 | 9,997.425 | 100,586.045 | 77,180.120 | 665,533.681 |

## ALTERNATIVE E4

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 33 | 5.06 | 1,063.720 | 1,063.720 | 5,382.425 | 5,382.425 |
| 34 | 5.24 | 998.680 | 2,062.400 | 5,233.084 | 10,615.509 |
| 35 | 5.39 | 938.719 | 3,001.120 | 5,059.698 | 15,675.207 |
| 26 | 5.47 | 880.917 | 3,882.037 | 4,818.615 | 20,493.822 |
| 31 | 5.59 | 3,046.505 | 6,928.542 | 17,029.965 | 37,523.787 |
| 25 | 5.73 | 1,669.934 | 8,598.476 | 9,568.721 | 47,092.508 |
| 22 | 5.75 | 855.518 | 9,453.994 | 4,919.230 | 52,011.737 |
| 24 | 5.85 | 13,341.343 | 22,795.337 | 78,046.857 | 130,058.594 |
| 27 | 5.86 | 774.143 | 23,569.480 | 4,536.478 | 134,595.073 |
| 28 | 6.29 | 2,414.993 | 25,984.473 | 15,190.306 | 149,785.379 |
| 23 | 6.30 | 3,078.710 | 29,063.184 | 19,395.874 | 169,181.253 |
| 13 | 6.46 | 2,900.555 | 31,963.738 | 18,737.583 | 187,918.836 |
| 29 | 6.49 | 4,196.681 | 36,160.419 | 27,236.458 | 215,155.294 |
| 30 | 6.55 | 867.902 | 37,028.321 | 5,684.759 | 220,840.053 |
| 12 | 6.55 | 5,672.290 | 42,700.611 | 37,153.501 | 257,993.554 |
| 10 | 6.56 | 699.607 | 43,400.219 | 4,589.424 | 262,582.978 |
| 14 | 6.72 | 4,679.952 | 48,080.170 | 31,449.275 | 294,032.252 |
| 16 | 6.78 | 4,737.588 | 52,817.758 | 32,120.848 | 326,153.100 |
| 19 | 6.89 | 1,368.637 | 54,186.395 | 9,429.906 | 335,583.006 |
| 18 | 6.99 | 666.772 | 54,853.167 | 4,660.734 | 340,243.740 |
| 9 | 7.17 | 1,252.500 | 56,105.667 | 8,980.426 | 349,224.166 |
| 11 | 7.17 | 716.606 | 56,822.273 | 5,138.066 | 354,362.232 |
| 21 | 7.20 | 627.495 | 57,449.768 | 4,517.965 | 358,880.197 |
| 17 | 7.26 | 2,137.202 | 59,586.970 | 15,516.086 | 374,396.282 |

ALTERNATIVE E4

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 32 | 7.47 | 5,294.565 | 64,881.535 | 39,550.399 | 413,946.681 |
| 36 | 7.54 | 9,997.425 | 74,878.959 | 75,380.584 | 489,327.265 |
| 20 | 7.76 | 689.348 | 75,568.308 | 5,349.342 | 494,676.607 |
| 15 | 7.83 | 7,155.536 | 82,723.844 | 56,027.847 | 550,704.454 |
| 8 | 8.13 | 6,217.680 | 88,941.524 | 50,549.737 | 601,254.191 |
| 7 | 8.19 | 578.790 | 89,520.313 | 4,740.286 | 605,994.477 |
| 3 | 9.45 | 2,530.963 | 92,051.276 | 23,917.604 | 629,912.081 |
| 5 | 9.49 | 449.008 | 92,500.284 | 4,261.082 | 634,173.164 |
| 2 | 9.89 | 2,347.529 | 94,847.813 | 23,217.061 | 657,390.225 |
| 6 | 9.92 | 2,351.978 | 97,199.791 | 23,331.620 | 680,721.846 |
| 4 | 10.02 | 397.480 | 97,597.271 | 3,982.749 | 684,704.595 |
| 1 | 10.09 | 804.655 | 98,401.925 | 8,118.965 | 692,823.560 |

ALTERNATIVE E5

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 33 | 4.92 | 1,063.720 | 1,063.720 | 5,233.505 | 5,233.505 |
| 34 | 5.09 | 998.680 | 2,062.400 | 5,083.282 | 10,316.786 |
| 26 | 5.21 | 880.917 | 2,943.317 | 4,589.577 | 14,906.363 |
| 35 | 5.29 | 938.719 | 3,882.037 | 4,965.826 | 19,872.188 |
| 31 | 5.47 | 3,046.505 | 6,928.542 | 16,664.385 | 36,536.573 |
| 22 | 5.60 | 855.518 | 7,784.060 | 4,790.902 | 41,327.475 |
| 25 | 5.63 | 1,669.934 | 9,453.994 | 9,401.728 | 50,729.203 |
| 27 | 5.71 | 774.143 | 10,228.137 | 4,420.357 | 55,149.559 |
| 24 | 5.72 | 13,341.343 | 23,569.480 | 76,312.482 | 131,462.042 |
| 28 | 5.91 | 2,414.993 | 25,984.473 | 14,272.609 | 145,734.650 |
| 23 | 6.05 | 3,078.710 | 29,063.184 | 18,626.197 | 164,360.847 |
| 12 | 6.26 | 5,672.290 | 34,735.474 | 35,508.537 | 199,869.384 |
| 13 | 6.33 | 2,900.555 | 37,636.028 | 18,360.511 | 218,229.895 |
| 29 | 6.38 | 4,196.681 | 41,832.709 | 26,774.823 | 245,004.718 |
| 10 | 6.40 | 699.607 | 42,532.316 | 4,477.486 | 249,482.205 |
| 11 | 6.40 | 716.606 | 43,248.923 | 4,586.279 | 254,068.484 |
| 30 | 6.45 | 867.902 | 44,116.825 | 5,597.969 | 259,666.452 |
| 17 | 6.48 | 2,137.202 | 46,254.027 | 13,849.068 | 273,515.520 |
| 16 | 6.49 | 4,737.588 | 50,991.615 | 30,746.947 | 304,262.468 |
| 14 | 6.61 | 4,679.952 | 55,671.566 | 30,934.480 | 335,196.947 |
| 18 | 6.69 | 666.772 | 56,338.338 | 4,460.702 | 339,657.650 |
| 19 | 6.76 | 1,368.637 | 57,706.974 | 9,251.983 | 348,909.633 |
| 9 | 6.87 | 1,252.500 | 58,959.475 | 8,604.676 | 357,514.309 |
| 20 | 6.98 | 689.348 | 59,648.823 | 4,811.651 | 362,325.960 |

ALTERNATIVE E5

| GROUP | RFR | DWT CAPACITY | CUMULATIVE CAPACITY | COST | CUMULATIVE COST |
|---|---|---|---|---|---|
| 21 | 7.03 | 627.495 | 60,276.318 | 4,411.291 | 366,737.251 |
| 15 | 7.03 | 7,155.536 | 67,431.854 | 50,303.418 | 417,040.669 |
| 8 | 7.32 | 6,217.680 | 73,649.534 | 45,513.416 | 462,554.085 |
| 7 | 7.36 | 578.790 | 74,228.323 | 4,259.891 | 466,813.976 |
| 32 | 7.40 | 5,294.565 | 79,522.888 | 39,179.779 | 505,993.756 |
| 36 | 7.44 | 9,997.425 | 89,520.313 | 74,380.841 | 580,374.597 |
| 6 | 9.00 | 2,351.978 | 91,872.291 | 21,167.801 | 601,542.398 |
| 2 | 9.01 | 2,347.529 | 94,219.820 | 21,151.236 | 622,693.634 |
| 4 | 9.05 | 397.480 | 94,617.300 | 3,597.194 | 626,290.827 |
| 3 | 9.11 | 2,530.963 | 97,148.263 | 23,057.076 | 649,347.904 |
| 1 | 9.13 | 804.655 | 97,952.918 | 7,346.496 | 656,694.400 |
| 5 | 9.16 | 449.008 | 98,401.925 | 4,112.910 | 660,807.310 |

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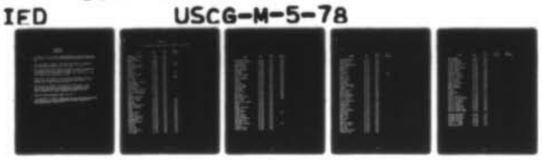

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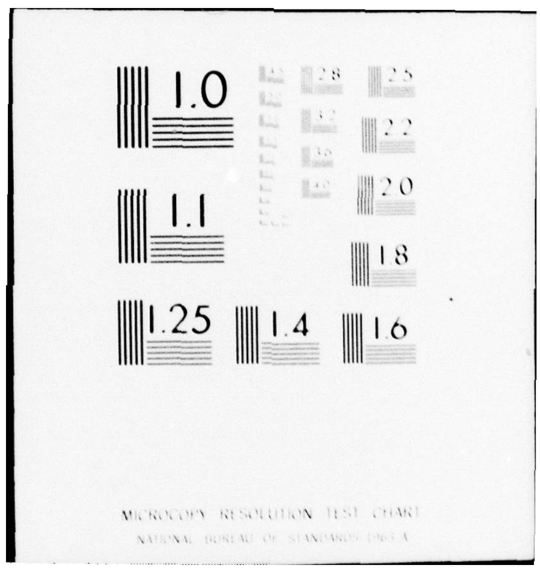
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

## APPENDIX E
## References


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3. IMCO, Marine Environment Protection Committee (MEPC), Introduction of Segregated Ballast in Existing Tankers, Presentation of a Joint Study by the Delegations of Greece, Italy, and Norway to the Fifth Session (May 1976), March 8, 1976.

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APPENDIX F

U. S. Unsubsidized Tanker Fleet (1,000 GRT - 40,000 dwt)

| Name | DWT | Year Built | Year Rebuilt |
|---|---|---|---|
| RAYMOND S. BUSHEY | 4,000 | 1938 | |
| A.H. DUMONT | 1,500 | 1940 | |
| GEORGE WHITLOCK | 1,500 | 1942 | |
| NECHES | 16,400 | 1943 | |
| GULFLION | 19,900 | 1944 | 1958 |
| TEXACO NEW JERSEY | 19,900 | 1944 | 1959 |
| PROVIDENCE GETTY | 3,900 | 1945 | |
| PURE OIL | 16,500 | 1945 | |
| LOMPOC | 16,700 | 1945 | |
| GUADALUPE | 16,700 | 1945 | 1963 |
| ALASKA STENDARD | 2,700 | 1959 | |
| GULFSEAL | 19,800 | 1945 | 1958 |
| GULFTIGER | 19,900 | 1945 | 1958 |
| F.L. HAYES | 1,500 | 1946 | |
| CHRISTIAN F. REINAUR | 1,900 | 1947 | |
| SANTA MARIA | 17,700 | 1952 | |
| HILLYER BROWN | 17,100 | 1953 | |
| KEYSTONER | 18,400 | 1953 | |
| TEXACO NORTH DAKOTA | 19,200 | 1953 | |
| LION OF CALIFORNIA | 16,200 | 1954 | |
| PHILLIPS WASHINGTON | 16,200 | 1954 | |
| AVILA | 17,600 | 1954 | |
| FRANCIS S. BUSHEY | 2,700 | 1955 | |
| MORRANA MARLIN | 2,000 | 1956 | |
| DAVID D. IRWIN | 24,300 | 1942 | 1961 |
| HOUSTON | 27,000 | 1942 | 1962 |
| MONMOUTH | 29,800 | 1942 | 1970 |
| AMOCO CONNECTICUT | 20,000 | 1943 | 1957 |
| AMOCO VIRGINIA | 20,100 | 1943 | 1957 |
| ARIES | 24,400 | 1943 | 1961 |
| VIRGO | 24,500 | 1943 | 1961 |
| TEXACO KANSAS | 24,700 | 1943 | 1960 |
| PERRYVILLE | 24,400 | 1943 | 1961 |
| CHANCELLORSVILLE | 25,200 | 1943 | 1961 |
| TEXACO MINNESOTA | 25,200 | 1943 | 1964 |
| MEADOWBROOK | 27,200 | 1943 | 1962 |
| AMERICAN TRADER | 27,600 | 1943 | 1967 |
| GULFDEER | 20,100 | 1944 | 1957 |
| TRINITY | 24,200 | 1944 | 1967 |
| CAPICORN | 24,500 | 1943 | 1961 |
| POINT JULIE | 24,600 | 1944 | 1961 |
| LOUISIANA GETTY | 25,100 | 1944 | 1968 |
| TULLAHOMA | 25,100 | 1944 | 1961 |

| Name | DWT | Year Built | Year Rebuilt |
|---|---|---|---|
| WILMINGTON GETTY | 25,200 | 1944 | 1968 |
| TEXACO MISSISSIPPI | 26,600 | 1944 | 1964 |
| SAN JACINTO | 26,900 | 1944 | 1962 |
| AMERICAN HAWK | 26,900 | 1944 | 1962 |
| TEXAS TRADER | 27,500 | 1944 | 1969 |
| AMOCO DELAWARE | 27,800 | 1944 | 1971 |
| OBSERVER | 28,300 | 1944 | 1966 |
| COLORADO | 30,400 | 1944 | 1972 |
| ATLANTIC TRADER | 20,000 | 1945 | 1958 |
| DAVID E. DAY | 20,000 | 1945 | 1958 |
| MOUNT EXPLORER | 23,400 | 1945 | 1961 |
| BRAZOS | 24,000 | 1945 | 1967 |
| PISCES | 24,400 | 1945 | 1962 |
| CONTIGINY | 25,500 | 1945 | 1962 |
| COUNCIL GROVE | 25,500 | 1945 | 1961 |
| FORT HOSKINS | 25,600 | 1945 | 1961 |
| PASADENA | 27,000 | 1945 | 1965 |
| SAN ANTONIO | 27,200 | 1945 | 1965 |
| AUSTIN | 26,900 | 1945 | 1962 |
| FORT WORTH | 27,600 | 1945 | 1968 |
| BRADFORD ISLAND | 32,700 | 1945 | 1971 |
| POINT MARGO | 33,800 | 1945 | 1968 |
| SAN MARCOS | 27,400 | 1949 | |
| COASTAL CALIFORNIA | 28,400 | 1949 | |
| SABINE | 28,700 | 1949 | |
| PECOS | 28,700 | 1950 | |
| MOUNT NAVIGATOR | 30,200 | 1951 | |
| THOMAS Q | 32,000 | 1951 | |
| EXXON NEWARK | 28,700 | 1952 | |
| THOMAS M | 25,200 | 1953 | 1971 |
| BIRCH COULIE | 26,600 | 1953 | |
| EXXON BANGOR | 28,700 | 1953 | |
| EXXON HUNTINGTON | 28,700 | 1953 | |
| DELAWARE SUN | 30,200 | 1953 | |
| NEW JERSEY SUN | 30,200 | 1953 | |
| OVERSEAS ALEUTION | 39,800 | 1953 | 1971 |
| ECLIPSE | 25,200 | 1954 | |
| DELAWARE GETTY | 27,400 | 1954 | |
| SOCONY VACUUM | 28,600 | 1954 | |

3

| Name | DWT | Year Built | Year Rebuilt |
|---|---|---|---|
| EXXON FLORENCE | 28,700 | 1954 | |
| NEW YORK GETTY | 28,800 | 1954 | |
| WESTERN SUN | 30,300 | 1954 | |
| COVE COMMUNICATOR | 31,900 | 1954 | |
| EASTERN SUN | 30,200 | 1957 | |
| MOBIL GAS | 26,900 | 1956 | |
| BANNER | 32,800 | 1956 | |
| ALLEGIANCE | 34,800 | 1956 | |
| POTOMAC | 27,500 | 1956 | 1964 |
| MOBIL POWER | 31,000 | 1957 | |
| MOBIL FUEL | 31,200 | 1957 | |
| SANTA CLARA | 33,000 | 1957 | |
| GULFKING | 34,700 | 1957 | |
| GULFQUEEN | 34,700 | 1957 | |
| EXXON JAMESTOWN | 37,700 | 1957 | |
| EXXON GETTYSBURG | 38,000 | 1957 | |
| KANSAS | 26,500 | 1958 | |
| FREDRICKSBURG | 28,100 | 1958 | |
| MOBIL LUBE | 29,200 | 1958 | |
| ARCO ENDEAVOR | 30,300 | 1958 | |
| ARCO ENTERPRISE | 30,300 | 1958 | |
| EXXON SEATTLE | 31,800 | 1958 | |
| GULF PRINCE | 33,100 | 1958 | |
| TEXACO WISCONSIN | 33,200 | 1958 | |
| GULFKNIGHT | 34,700 | 1958 | |
| SANTA PAULA | 34,900 | 1958 | |
| CHILBAR | 33,700 | 1959 | |
| CONNECTICUT | 37,600 | 1958 | |
| EXXON LEXINGTON | 37,000 | 1958 | |
| GULFPRIDE | 29,200 | 1959 | |
| GULFSOLAR | 29,200 | 1959 | |
| MOBIL AERO | 30,100 | 1959 | |
| MOBIL OIL | 30,100 | 1959 | |
| GULFCREST | 30,800 | 1959 | |
| METON | 33,700 | 1959 | |
| AMERICAN EAGLE | 33,100 | 1959 | |
| ERNA ELIZABETH | 33,200 | 1959 | |
| GULF OIL | 29,200 | 1960 | |
| GULFSPRAY | 29,200 | 1960 | |
| OGDEN CHALLENGER | 33,300 | 1960 | |
| OVERSEAS ULLA | 35,700 | 1960 | |

4

| Name | DWT | Year Built | Year Rebuilt | Year Scrapped |
|---|---|---|---|---|
| GULFSUPREME | 30,800 | 1961 | | |
| ARCO PRESTIGE | 34,100 | 1962 | | |
| TEXACO MARYLAND | 25,400 | 1963 | | |
| TEXACO MASSACHUSETTS | 25,700 | 1963 | | |
| TEXACO GEORGIA | 25,200 | 1964 | | |
| TEXACO RHODE ISLAND | 25,400 | 1964 | | |
| TEXACO MONTANA | 26,600 | 1965 | | |
| VALLEY FORGE | 36,000 | 1966 | | |
| OVERSEAS ALICE | 37,300 | 1968 | | |
| OVERSEAS VALDEZ | 37,800 | 1968 | | |
| SPIRIT OF LIBERTY | 38,200 | 1968 | | |
| OVERSEAS VIVIAN | 37,800 | 1969 | | |
| EAGLE LEADER | 37,800 | 1969 | | |
| EAGLE CHARGER | 37,800 | 1969 | | |
| OGDEN WILLIAMETTE | 37,900 | 1969 | | |
| OGDEN WABASH | 37,900 | 1969 | | |
| OGDEN CHAMPION | 37,900 | 1969 | | |
| NECHES | 37,320 | 1971 | | |
| COLOMBIA | 37,300 | 1971 | | |
| SUSQUEHANNA | 37,300 | 1972 | | |
| HUDSON | 37,300 | 1972 | | |
| SEALIFT PACIFIC | 27,300 | 1974 | | |
| SEALIFT MEDITERRANEAN | 27,200 | 1974 | | |
| SEALIFT ATLANTIC | 27,200 | 1974 | | |
| SEALIFT CARIBBEAN | 25,000 | 1975 | | |
| SEALIFT ARCTIC | 25,000 | 1975 | | |
| SEALIFT ANTARCTIC | 25,000 | 1975 | | |
| SEALIFT CHINA SEA | 25,000 | 1975 | | |
| SEALIFT ARABIAN SEA | 27,300 | 1975 | | |
| SEALIFT INDIAN OCEAN | 27,300 | 1975 | | |
| CHEVRON WASHINGTON | 39,600 | 1976 | | |
| CHEVRON COLORADO | 34,500 | 1976 | | |
| CHEVRON LOUISIANA | 39,500 | 1977 | | |
| CHEVRON ARIZONA | 39,600 | 1977 | | |
| MARTHA R. INGRAM | 36,500 | 1971 | | |
| CAROLE D. INGRAM | 36,500 | 1972 | | |
| EXXON GALVESTON | 19,200 | 1970 | | |